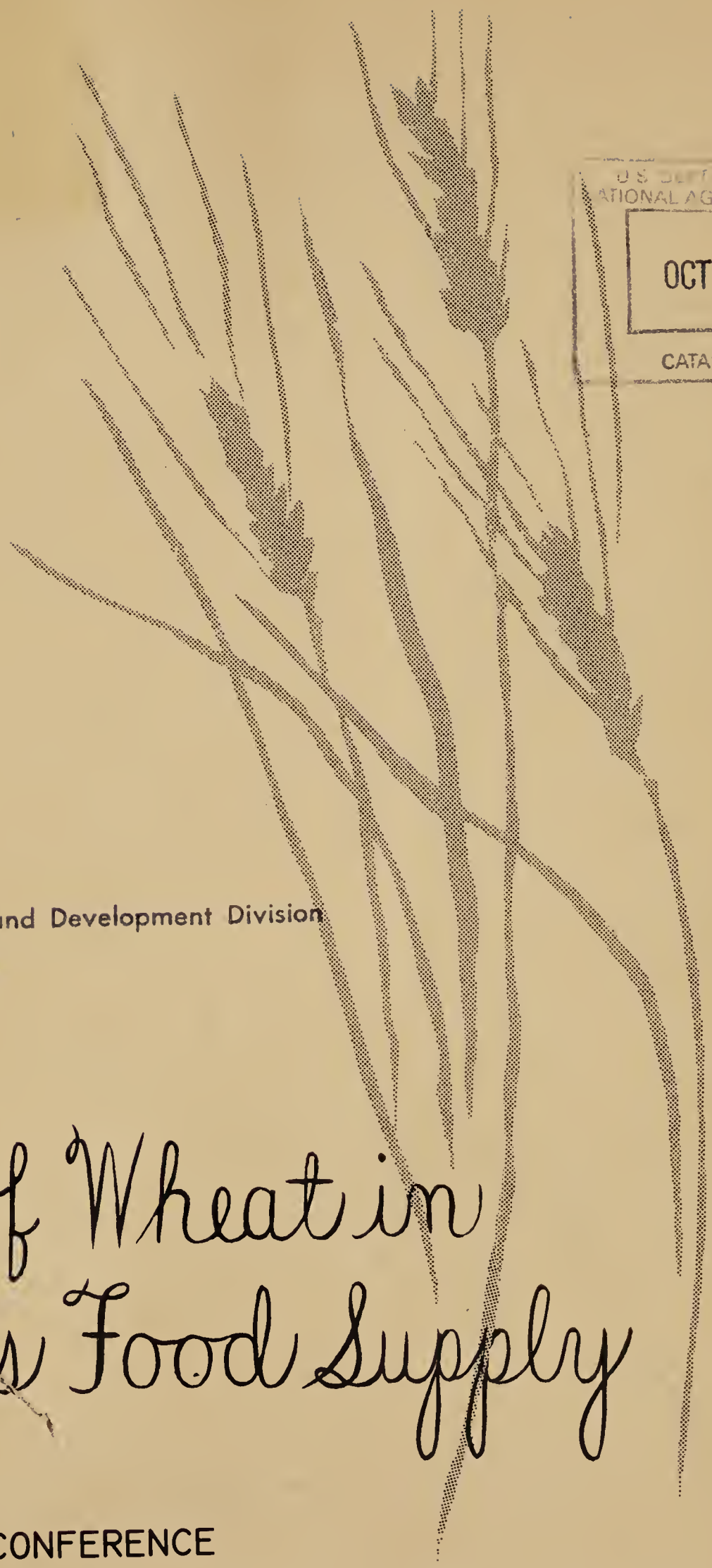

Conference on the

Role of Wheat in World's Food Supply

REPORT OF CONFERENCE

APRIL 30 TO MAY 2, 1962 AT ALBANY, CALIFORNIA

THE CONFERENCE ON THE ROLE OF WHEAT IN THE WORLD'S FOOD SUPPLY was held April 30 to May 2, 1962, at the Western Regional Research Laboratory in Albany, California. It had its initiation in a resolution of the National Association of Wheat Growers, meeting December 1961 at Boise, Idaho, as follows:

"WHEREAS, the world food budget requirements are of concern to the people of the world, and

"WHEREAS, wheat can be utilized to help meet the food requirements of certain food deficient areas of the world: Now, therefore, be it

"RESOLVED, That a conference be sponsored by the National Association of Wheat Growers, Western Wheat Associates, Great Plains Wheat, USDA agencies and other interested groups, to expand the use of wheat from our country in meeting the food budget requirements of the world through the regular export programs of our country and the Food for Peace programs."

Responding to this resolution, Dr. M. J. Copley, Director of the U. S. Department of Agriculture's Western Utilization Research and Development Division, and Howard Morton, Director of Utilization Research for Great Plains Wheat, Inc., initiated plans for a conference on THE ROLE OF WHEAT IN THE WORLD'S FOOD SUPPLY. As a preliminary action, the National Association of Wheat Growers, Western Wheat Associates, Inc., and interested agencies of the U. S. Department of Agriculture were asked to join in sponsoring and planning the conference.

The Western Regional Research Laboratory of the U. S. Department of Agriculture at Albany, California was selected as a site for the conference and, from the Laboratory staff, R. L. Olson was directed to organize a tentative program with guidance from G. O. Kohler and J. W. Pence. Following endorsement of the sponsors, the program was developed in final form. R. H. Nagel arranged for local facilities.

Exemplary cooperation and assistance were obtained from authorities in economics and nutrition, and from food scientists, whose names are found in this report in connection with their presentations, and whose participation is gratefully acknowledged.

This report was prepared by D. F. Houston assisted by C. C. Nimmo and D. K. Mecham and edited by R. T. Prescott in the Western Utilization Research and Development Division, Agricultural Research Service, USDA. Copies are available on request from Western Regional Research Laboratory, Albany 10, California, headquarters of the Division.

May 1962.

PROGRAM AND CONTENTS

ROLE OF WHEAT IN THE WORLD'S FOOD SUPPLY

Report of Conference

INTRODUCTION

M. J. Copley
Western Regional Research Laboratory, USDA, Albany, California

Markets for U. S. wheat must be expanded; our wheat production continues to exceed our domestic needs, resulting in overabundance in spite of controls. And yet while we complain about our surpluses, in many countries there is hunger and starvation. How to get our life-saving grain out of our bins and storage houses and into the millions of hungry mouths of the world's famine-stricken people is our problem and our great challenge. Over the past few years, exports of wheat and wheat products have increased as the result of a number of programs. Examples are the government-sponsored shipments of surplus foods, feeding of the underprivileged by volunteer agencies, surveys of nutritional status in various developing countries, and research to develop suitable products and evaluate new markets. The objectives have been varied, ranging from those that are strictly humanitarian and instrumental in foreign policy to long-range market activities to develop commerce. Some programs have been closely coordinated; some have been parts of larger programs with only coincidental coordination where interests overlap. Increasingly, the agencies and institutions concerned have drawn together to reach common objectives.

To encourage coordination and to make programs more effective the several sponsors organized this conference. It was their considered judgment that there is insufficient understanding of the need for wheat in large-scale international food programs, of the unique availability of wheat, of the nutritional values of wheat, and of the possibilities of using wheat in different forms to meet local traditions of food use.

Objectives are to clarify these important points and to provide: (1) a summary of available information on international food requirements; (2) a review of activities of governmental, agricultural, and industrial organizations in developing international trade in wheat and wheat products; (3) a discussion of potential overseas wheat markets; and (4) a presentation of technical information on nutritive qualities and the conversion of wheat to useful food products.

OPENING REMARKS--SESSION ON WORLD'S SUPPLY AND USAGE OF FOOD

Glen Bayne, President
National Association of Wheat Growers, Washington, D. C.

Wheat plays a major role in the lives of most of us assembled here. For many, it is our chief means of livelihood. Wheat also plays a great role in feeding the world's populations. How large it is in various parts often escapes those who are closely connected with a particular phase of wheat production or utilization. This conference will help us reorient our thoughts, broaden our outlook, and see how United States wheat can achieve greater use in the world.

The National Association of Wheat Growers, which I represent, operates in 11 states that produce 55 percent of U. S. wheat. We are proud to co-sponsor this conference with Great Plains Wheat, Inc., Western Wheat Associates, Inc., and agencies of the U. S. Department of Agriculture concerned with economics, utilization, and marketing. I want especially to express our appreciation to Dr. M. J. Copley and his assistants for assembling this fine list of speakers and to Howard Morton for his effective activities in developing the conference.

The objectives and the discussions are excellently oriented towards our more comprehensive understanding and interpretation of the role of wheat. Our exchanges of information will provide a better realization of the problems and their solutions.

THE WORLD FOOD PARADOX

Sherman E. Johnson
Deputy Administrator for Foreign Economics
Economic Research Service, U. S. Department of
Agriculture, Washington, D. C.

A world view of the present agricultural scene presents a double paradox. In many of the less developed countries, there is a shortage of food despite great physical potentialities for increasing food production. Contrast this situation with the United States and other countries where farming is carried on with modern technology. Here the incomes of farm people are depressed by supplies in excess of available markets.

Chronic food shortages should not be tolerated in any country because for the first time in human history it is physically possible to provide adequate food supplies for all the inhabitants of the world. But achievement requires use of modern technology. In most of the underdeveloped countries, adoption of improved farm technology would result in tremendous increases in food output. However, the present primitive production methods result in low yields, and the great masses of people are living on the margin of subsistence. Their entire lives are occupied with the struggle for "daily bread." Their inability to free themselves from the threat of hunger endangers both the economic and the political stability of many countries.

In striking contrast, adoption of improved technology has resulted in abundant production in the countries with highly commercialized agriculture. Output in recent years has exceeded available markets. Consequently, prices have declined and farm people are not receiving their proportionate shares of the fruits of progress. Some temporary relief for food-shortage countries has been provided by food aid from food-surplus countries. But eventually food imports must be paid for with foreign exchange. Therefore, most of the long-term solution for the food-deficit countries must be sought in expanding their domestic food production by adoption of improved technology.

Many agricultural leaders have struggled with the paradox of either want or plenty. The United Nations Conference on Food and Agriculture which was held in Hot Springs, Virginia, May 17-June 3, 1943, made "Freedom from Want" its primary goal. The information report of the Conference stated that: "The delegates at Hot Springs began with Freedom from Want and with the first condition for Freedom from Want, the opportunity of every man to have enough food for himself and his family. . . . Two-thirds of the people of the world spend their lives on the land, raising food. And two-thirds of the people of the world, including many who live on the land, have never had enough to eat.[1/]

We have made some progress since this first FAO Conference was held in the midst of World War II. But available information indicates that about three-fifths of the world's population are now living in areas with serious food shortages. We still have a long way to go to achieve the goal of freedom from want for all people.

The present Freedom from Hunger campaign of FAO is an up-to-date attempt to deal with the problem of want, primarily by encouraging increases in production in food-deficit countries, but also by mobilizing supplies from the food-surplus countries. And FAO is the chief sponsor of a $100 million, three-year, multilateral food-aid program.[2/]

1/ "A Start Toward Freedom From Want." The Story of the United Nations Conference on Food and Agriculture, 1943.

2/ See Freedom From Hunger Campaign News, Vol. 2, No. 9. December 1961.

Recognizing that an understanding of the problem is the first requirement for intelligent action, the U. S. Department of Agriculture in 1961 requested the Regional Analysis Division of the Economic Research Service to spearhead a study of world food deficits and to prepare a world food budget. Utilizing all available information in the Department of Agriculture and from other sources, "The World Food Budget, 1962 and 1966" was prepared and published in October 1961.3/

As a first step, this report summarizes total food supplies available for human consumption from all sources, country by country. It then relates these food supplies to population in order to obtain per capita consumption. The statistical bases for this determination were the food balance estimates compiled by the Department of Agriculture, by commodity or groups of commodities for some 80 Free World countries and for the Communist bloc. The consumption year 1958 served as the base year for food balances in most countries. For each country, the food balances show domestic production plus imports, minus exports, plus or minus changes in stocks, and the total supply available for all uses. After deducting quantities used for feed, seed, waste, and industrial purposes, the remaining supplies were broken down on the basis of population. In this way the calories available per day per person were arrived at on a national basis.

Production of major foodstuffs was projected for each country to 1962 and 1966. These projections were based on trends in output of individual commodities, examination of plans by foreign governments for increasing production, and estimates of likelihood of adoption of improved practices. The production projections reflected the judgment of country and commodity specialists concerning the relative importance of many factors affecting future output. Population projections were based on the best available estimates of population trends in each country.

In many countries data were incomplete, but estimates were based on the best available information, which frequently was obtained from scattered sources. This was especially true for Communist Asia. Despite weaknesses in data, the estimates of average food intake per person appear to gauge fairly well the principal food deficits in different countries.

A second task was that of measuring the foods available to people in food-deficit countries against the amounts and types of food needed to maintain normal health and activity in their own environment. For this purpose, per capita nutritional reference standards were established, by countries or groups of countries, by calories, animal and vegetable proteins, and fats. The reference standards for calories were based on requirements as developed for 36 countries by FAO. When projected for all countries, the reference standards varied from 2,710 calories in Canada and the Soviet Union, to 2,300 calories in the Far East and Communist Asia. The reference standard for total protein was 60 grams per person per day and was used as a minimum for all regions. Of this amount, the reference standard included 17 grams of animal and pulse protein, with at least 7 grams of animal protein. The standard for fat was set for all regions at 15 percent of the calorie standard, but this was regarded as a nutritional floor rather than a desirable goal.

The estimated national average food consumption per person was measured against the reference standard. This method provides no information on variations in consumption among different groups within each country. Even in countries with average supplies per person at or above the reference standard, there are groups of people whose diets fall below the established standard. This point is illustrated by the situation in northeast Brazil.

3/ Foreign Agricultural Economic Report No. 4. Economic Research Service in cooperation with Foreign Agricultural Service, U. S. Department of Agriculture. October 1961.

If food deficits were expressed in terms of all the foods that people eat in different countries, the resulting data would be almost unmanageably detailed. For the sake of greater simplicity, the food budget analysis translated world shortages of various foods into nutritional equivalents of a few widely known and used foods. Thus, animal protein deficits were expressed in terms of nonfat day milk; vegetable protein deficits in terms of dried beans and peas; fat in terms of vegetable oil; and other protein and calorie deficits in terms of wheat.

Summarizing results of the study, we find that 40 countries had adequate food supplies in 1958, either from domestic production or commercial imports. Some of these countries were large exporters of foodstuffs; others were dependent on commercial imports to supplement domestic production. Seventy countries and territories were in the food-deficit category. Production, trade, and consumption were projected for 1962 and 1966. The following tabulation shows by world regions the percentages of the total nutritional gap as projected for 1962; also the percentages of projected world population:

Region	Population Percent	Nutritional Gap Percent
Latin America	10	6
Africa	11	6
West Asia	4	3
Far East	42	60
Communist Asia	33	25
	100	100

It is evident that the world food problem centers primarily in the Free Far East and Communist Asia. Two-thirds of the cereal shortage (computed in terms of wheat) is projected for the Free Far East both for 1962 and 1966. It also has nearly half of the animal and vegetable protein and fat deficits.

Because most people in the food-deficit countries subsist largely on vegetarian diets, the cereal deficit is a fairly good index of the size of the food gap. We must bear in mind, however, that serious shortages of animal and vegetable proteins result in malnutrition even when cereal supplies are sufficient to meet the calorie reference standard. In the food-shortage countries, the cereal deficit above commercial shipments was estimated as about equivalent to 1.4 billion bushels of wheat for 1962 (excluding Communist Asia).

Perhaps we can gauge the size of this food gap a little better if we compare it with the current wheat production potential in this country. Suppose we take our all-time wheat acreage record of 75.9 million harvested acres in 1949 and assume yields of 20-22 bushels per acre. This assumed yield is below current levels in recognition of the fact that yields would be lower with a maximum acreage than under acreage allotments. Under these conditions, our total wheat production would be 1.5 to 1.7 billion bushels. It appears that the 1962 cereal gap is about equivalent to a U. S. wheat crop on 75 million acres.

The assumed yield of 20-22 bushels per acre, or 1,200 to 1,300 pounds, is nearly twice the average yield per acre in India or Pakistan, and about equal to the yield of paddy rice in those countries. Another way of expressing the size of the 1962 cereal food gap would be to say that the tonnage is roughly equal to 55 percent of the present production of rice, wheat, and coarse grains in India. In addition to the cereal deficit, there are large gaps in present consumption as compared with nutritional reference standards in animal and pulse proteins as well as in fats.

Why are we concerned about wheat and feed grain surpluses, with a world cereal deficit of this magnitude? Isn't this a glorious opportunity to get rid of the wheat surplus? It has been a perennial problem ever since World War I, with the exception of some World War II and rehabilitation years, including the Korean crisis. Why not at least get rid of accumulated stocks by shipping them to food-deficit countries under the P. L. 480 program? This group is well aware of some of the fallacies in this suggestion, but perhaps it is worthwhile to mention some of them in passing.

First of all, the receiving countries are not willing to accept food aid that will end as soon as our stocks are exhausted. This might leave them in an even more vulnerable position than before acceptance of food aid, because consumers then would be accustomed to more adequate supplies. Consequently, receiving countries are interested in a continuing program with specific quantity guarantees, such as the 4-year India program.

Even if receiving countries were willing to take our surplus stocks, their unloading facilities, warehouses, transportation, and distribution facilities would not be adequate to handle them. And most receiving countries would not be in a position to use them effectively in economic development. Surplus stocks, therefore, can only be disposed of over a period of years.

Moreover, four-fifths of the Free World food deficit is in the Far East; and rice is the staple diet of most people in these countries. This audience is well acquainted with the task involved in changing food habits. It can be done, but food habits of long standing are barriers even to the most effective use of domestic food resources.

Let us assume for the moment, however, that satisfactory arrangements could be made to continue shipments to receiving countries of enough wheat to gradually work down surplus stocks (including potential annual increments). Would public opinion in the United States support legislation to carry out such a large-scale program? I shall leave this question unanswered, but it is my personal opinion that it would be quite unrealistic to assume either that all of U. S. wheat surplus problems can be solved, or that food shortages in the less developed countries can be remedied, by a stepped up P. L. 480 program.

Most of the food gap in deficit countries will have to be filled by increasing their domestic production. If this is to be accomplished, production in these countries will need to increase enough to overcome most of the deficit, and also to provide for a rapidly increasing population. This herculean task cannot be carried out immediately, and food aid does have a place in relieving food shortages during the transition years. In fact, P. L. 480 type food-aid programs have a unique role to play in economic development programs of food-shortage countries. This will be seen more clearly if we describe the early steps in a development program.

We have learned that aid programs granted on a year-to-year basis for isolated projects have not been very effective in helping receiving countries to achieve self-sustaining economies. We now recognize that effective aid must be fitted into a plan for economic development which if carried out over a period of years will enable the receiving country to increase production and income sufficiently to balance its imports with exports of goods and services. But if a food shortage occurs in the early stages of national economic development, it can become an effective barrier to economic growth.

Suppose a densely populated and underdeveloped country decides to make a large investment in new industrial plants, and at the same time to improve its system of transportation and communications. The construction phase of such development creates additional employment and increased purchasing power of workers. A

high percentage of the increased income of workers will be spent for food, and if larger food supplies are not available, the rising prices of food will generate an inflationary spiral that will retard economic development. India experienced such a sequence of events in 1958-59. Apparently, similar situations have developed in Iran, Indonesia, and some other countries.

More food can be obtained either from increased domestic production or from imports. But domestic production is not likely to respond fast enough to meet the rising demand in the early years of development. And commercial imports are limited because of the scarcity of foreign exchange. The available foreign exchange is needed to import equipment for plant construction. Under such conditions, Title I of P. L. 480 food programs can play its unique role in an integrated program to accelerate economic growth. Food can be made available to meet the increased demands and thus prevent upward spiraling of food prices. And most of the proceeds from the sale of P. L. 480 products usually are made available in the form of loans or grants to the receiving country for investment in further economic development.

The construction phase of an economic development program is a necessary part of improvement of agriculture as well as industry. There is a great deal of under-employment in the rural villages of densely populated countries where 70 to 80 percent of the total population is directly dependent on agriculture. Some of the under-employed workers could be given employment on building farm-to-market roads, local storage facilities, small irrigation projects, and other improvements that will increase the efficiency of agriculture at the same time as total output is increased. Such improvements could be carried out largely with hand labor and use of local materials. Much of it would have to be financed as public works projects. But food aid programs could help to finance such projects. In other words, the proceeds from sale of P. L. 480 shipments could furnish part or all of the funds for agricultural improvement programs of this type.

Perhaps someone will raise the question: Why are we interested in economic development of these countries? I would say, first of all, because we are a part of the Free World community. It is my personal belief that the Free World, as we know it, cannot endure permanently with more than half of the people living in countries which are chronically short of food. Food aid can provide significant temporary improvement if the governments of receiving countries are willing and able to use it for this purpose. But more important, it can help build a foundation for permanent improvement of income and welfare.

A second reason for our interest in economic development is our concern for the long-term welfare of American farmers. With average weather, our food production capacity will exceed our prospective domestic and foreign commercial markets for many years to come. We are, therefore, interested in enlarging our markets for farm products, even though we recognize that food aid is not a complete panacea for our wheat and feed grain surpluses.

If food and fiber can effectively contribute to economic development that will result in building self-sustaining economies in the presently underdeveloped nations, total trade will increase. Eventually this is likely to result in larger commercial markets for our farm products. We have already seen this transition taking place in Japan and Italy. It is underway in Spain.

Preliminary findings from a study being conducted in the Economic Research Service indicate that from 1950 to 1960 a 10-percent rise in per capita income in low-income countries was associated with slightly more than a 10-percent rise in per capita imports of agricultural products from the United States. Countries with

incomes of $100-$200 per capita import only $1-$2 worth of farm products per capita from the United States, whereas countries with per capita incomes of $800-$1200 import $8-$12 of farm products per capita.4/

The period of transition to a self-sustaining economy is likely to be of rather long duration in the Far Eastern countries, but eventually self-sustaining economies must be established, or they are not likely to remain in the Free World orbit. They will need our help to accelerate improvements both in agriculture and industry. But once the economy gets on the high-speed track of accelerated growth, both the increase in population and the gradual upgrading of diets will push in the direction of larger food demands. These demands can then be met, mostly by increased domestic production, but partly by shifting from food aid to commercial imports. Farmers in the United States will then share in the larger commercial trade in farm products, if we are willing to take other goods and services in exchange for food.

If we take this approach to food aid, it will involve a basic shift in public understanding of the reasons for P. L. 480 type food aid programs in the United States--a shift from regarding them as temporary surplus disposal operations to thinking of them as food for economic development in the broad setting of helping underdeveloped countries to achieve self-sustaining economies. We will no longer be worried about expansion of output of competing products in receiving countries, because we will realize that balanced economic growth results in larger markets for domestic production as well as for imports.

The receiving countries also will need to change their attitudes toward food aid. In some countries there is now an inclination to regard the acceptance of food aid as a favor to the United States. We have promoted this attitude by continuously harping on our surplus problem. But we are using U. S. labor, land, and capital resources to provide food aid. These resources are not costless. They should not be made available if they cannot be used effectively in the receiving country.

Effective use of food in the receiving country involves much more than its acceptance to supplement commercial imports in order to save foreign exchange; specific provision must be made for receiving, storing, transporting, and distributing food aid in order to maximize its contribution to economic development.

If food aid is regarded as an integral part of a program of assistance to achieve rapid economic development, it can become a means of breaking the food barrier to economic progress. But it will not serve that important purpose unless public opinion and government agencies in the United States and the receiving countries are aware of the unique opportunities, and develop programs to realize them.

Discussion. Questions were concerned with effect of the land tenure situation on development of improved agricultural methods in underdeveloped countries, the degree of our responsibility for feeding and otherwise helping these countries, the effect of long term aid (5-10 years) as a possible deterrent to local effort, effectiveness of food price increases in stimulating production, elimination of illiteracy, population growth vs. food supply, and possible revision of P. L. 480 to encourage long range aid. The following represents views expressed on these questions.

Land tenure and its effect on incentive and initiative of people were described as variable. In some countries it is important that adjustment will be required before progress can be made. Land tenure is basic in Iran, for instance, but is not the greatest problem in India. Interest rates on money for agriculture may be very

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4/ Unpublished analysis by Arthur B. Mackie, Development and Trade Analysis Division, Economic Research Service.

high. The grower usually must sell the crop at harvest. A large output may drive the price down, since good storage may not be available.

The view was expressed that feeding of peoples of Asiatic countries is not wholly our responsibility. The problems were described as connected with poverty and illiteracy. It was the speaker's opinion that if compulsory education had begun in India about 1900, trained people would now be available to assure economic development, and India might have had neither the population nor the pressure on resources that she has today. We ought to offer help to those who are receptive and willing to start their own program of self-help. The United States is trying to induce other Western countries to share the responsibility.

The government of the receiving country must realize that aid is only a first stage in domestic development and a partial solution. India's planning commission, for example, is aware of this fact. She is building fertilizer plants to increase crop output as rapidly as possible. Where India has 2 to 2-1/2 percent annual population increase, the Philippine Islands has 3 percent.

Some countries are doing well in reducing illiteracy. Indonesia's program is commendable, and India has an ambitious program. It is a big job to reach 600,000 villages. The United States could do more in aid of basic primary education; we have done better in higher education.

Increases in food supply apparently do not go together with population growth. Sociologists have observed that an increase in population is evident even under conditions of semi-starvation.

If revision of P. L. 480 to provide for longer term projects were desirable, its accomplishment would present some difficulties. The opinion was given that the program might be thought of in terms of aid to market development, with the hope that a country put on a self-sustaining basis might become an expanding market for some of our products.

INTRODUCTION TO SESSION ON FOOD SUPPLY AND NEEDS

George W. Irving, Jr.
Deputy Administrator, Agricultural Research Service,
U. S. Department of Agriculture, Washington, D. C.

This morning, Dr. Sherman Johnson's presentation of the World Food Paradox set the stage for our conference by providing a broad factual foundation for the rest of our deliberations. Tomorrow and Wednesday we will discuss how wheat can be utilized to give man a bigger portion of his daily bread, but in today's panel session--a necessary forerunner to considering how best to use wheat--we will hear "Observations on the food traditions, supply and needs in several areas of the world." It is the aim of the panel experts to inform us, of course, but also to stimulate discussion which is a major purpose of the conference. We are most anxious to have a wholehearted, vigorous discussion this afternoon.

May I also urge that your questions and comments be directed so as to clarify issues implied by the session topic. There will be ample opportunity in subsequent sessions to discuss other objectives and we are hoping to confine ourselves today to a thorough airing of views on this one.

There are obvious questions in today's topic upon which we may anticipate some enlightenment: What foods now serve to sustain mankind? What are the unique problems of various areas with respect to food sufficiency? To what extent are food traditions inviolable? Where food shortages exist, how much of the shortage is caloric and how much deficiency of nutrient balance? Is it possible that voluntary food contributions to underdeveloped nations can lead to long-range problems more difficult than the existing ones?

Is it humanitarian in the long run to provide food to sustain life and even increase a poverty-stricken population without providing resources and knowledge to enable this population ultimately to sustain itself in world market competition? If our national abundance is to be used in meeting requirements in food-deficient areas, it would seem that full consideration should be given to pathfinding an economic recovery that will make it possible ultimately for these areas to pay their own way. Sherman Johnson has already alluded to this. In the observations of this afternoon's panel I'm sure we can expect some additional guidance.

We have among us today representatives of organizations who have been prominently concerned with market development in food-deficient areas of the world. In particular, Great Plains Wheat, Inc. and Western Wheat Associates, Inc. have been active for several years in introducing wheat and knowledge through school lunch programs--and introducing raised bread and bulgur to many lands where they had not been known. The Department of Agriculture, using counterpart funds through P.L. 480, has been a major factor, of course, in many such programs. The special problems of infant malnutrition have been faced by the United Nations Children's Fund, which has been most concerned with improving each area of need with programs to overcome deficiencies with native resources. In addition, private enterprise (DCA Industries, Inc., for example) has entered into programs of developing markets that will also extend knowledge and encourage development of native resources to overcome deficiencies. The experiences of all will be well worth hearing about in our discussions today.

I should like to make two points in anticipation of the sessions of the conference to follow. First, although it's true that we are talking today about food in general, we should ask as we go along--What values and opportunities has wheat to meet the specific food requirements of food-deficient areas of the world?

We should not forget that supplementing native diets of many areas where starchy foods make up much of the diet, use of wheat will result in a relative protein improvement. This should be kept well in mind when considering nutrient balance and caloric requirements.

In this regard, another series of questions may be asked: Does kwashiorkor exist among the poverty-stricken in wheat-eating areas of the world? Do the cassava and rice eaters have fuel supplies to boil raw wheat, and the technical means for debranning parboiled wheat? Will the islanders eat wheat starch paste as a substitute for poi? Can either of these groups be converted to eating bread?

No standard procedure can be applied to improve all local situations. Each area and location must be considered as a separate problem with a unique solution. The personal observations of today's speakers may shed much light on these questions.

My second point is this. The conversion of wheat to bulgur and other products appears to provide the solution to some of these problems. It is appropriate that we are meeting here at the Western Regional Research Laboratory where interest in bulgur as a means for increasing wheat utilization is twelve years old this year. Some of the studies conducted here will be discussed Wednesday, using the frame of reference established by today's speakers, for consideration of the potential use of wheat products.

I have one final observation; the near-astronomical data reflecting food requirements in the world today bring another factor into focus. Generally speaking, it is not feasible to accumulate food. Food is to be harvested and consumed. The composite pantry of mankind contains only one substance whose supply has any significance against the potential demand for food, and that is cereal grains stored in the United States. Even this abundance will not meet world needs on a continuing basis. Other resources might be developed if incentives were high enough. Until those incentives can be developed, however, all solutions to balancing the World Food Budget must include ample consideration of a current availability of wheat.

We may consider here today, then, three essentials of an effective world food program: (1) Development of economic stability to provide continuing markets and self-sustaining populations; (2) Conversion of some of the food available for supplying world needs to new products more acceptable to people of widely varying food habits; and (3) Recognition that wheat must play a dominant role in the foreseeable future in any large-scale food program to be developed.

FOOD CONSUMPTION AND NUTRITIONAL STATUS IN ASIAN COUNTRIES IN RELATION TO THE NEED FOR U. S. AID

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Geneva, New York

In early 1955 the Interdepartmental Committee on Nutrition for National Defense (ICNND) was established by a memorandum of agreement by the Departments of State, Defense, Agriculture, Health, Education and Welfare, and the Administration for International Development (9, 1960). The committee was later joined by the Atomic Energy Commission and recently by the Food for Peace organization.

The purpose of this committee as set forth in the memorandum of agreement, is to supply assistance in nutrition problems of technical, military, and economic importance in foreign countries. The committee is advised by a panel of consultants of which I am one, who are specialists in nutrition, medicine, agriculture, food technology, and biochemistry.

In all of its surveys the Interdepartmental Committee on Nutrition for National Defense has worked closely with the United Nations agencies. Among these the Pan-American Health Organization, the United Nations Children's Fund, and the Food and Agriculture Organization have appointed liaison representatives to the Committee.

Nutrition surveys will have been completed in twenty-one countries by July 1, 1962 including four in the Near East, six in the Far East, and one in the Middle East (Figure 1).

Figure 1. Countries surveyed by Interdepartmental Committee on Nutrition for National Defense prior to July 1, 1962.

In general, the survey teams have consisted of physicians for the observation of nutritional deficiency symptoms, biochemists (laboratory director and two or more assistants) for analysis of blood and urine samples, food-service and nutrition specialists for collecting data on consumption patterns, and a food technologist or agricultural specialist for examining the situation with respect to the production and processing of foods.

Personnel of the host country are given training by working side by side with U. S. team members. The laboratory equipment is left with the host country, and

projects are initiated which are continued after completion of the initial survey. The procedures followed are described in a Manual of Nutrition Surveys (5, 1957). In follow-up activities, the Committee makes consultant service available to assist further in specifically designed problem areas.

Country comparisons of average cereal consumption patterns. In general the dietary patterns in Asian countries, in comparison with Western Europe, are high in cereal content. The cereals serving as the main staple food in these areas are wheat and rice.

Except in the Far East, wheat is the principal cereal produced in all countries in the temperate zone. In the Near East wheat is almost the sole cereal consumed in diets in which cereals generally supply between 60 and 70 percent of the calories (Table 1). In the Middle East, cereal consumption is more diversified (Table 2).

Table 1. Consumption of cereals in Near Eastern countries[1/]

	kg./caput/year				Percent of calories from cereals
	Wheat	Corn	Rice	Other cereals	
Iran	110.9	-	16.2	12.9[2/]	65.9
Iraq	111.9[3/]	0.9	20.1	22.4[2/]	66.1
Israel	118.3[3/]	-	5.0	0.5	43.8
Jordan	112.9[3/]	-	9.8	15.8[2/]	63.5
Lebanon	150.5[3/]	1.3	9.1	7.1[2/]	66.7
Syria	120.7	0.6	7.2	22.9[2/]	64.7
Turkey	155.9	10.1	2.4	22.7[2/]	69.0

1/ Food balances in foreign countries (2). 2/ Mostly barley. 3/ Largely imported.

Table 2. Consumption of cereals in Middle Eastern countries[1/]

	kg./caput/year			Percent calories from grains
	Rice	Wheat	Sorghums and millets	
Pakistan	96.7	40.4	5.5	73.0
India	69.5	22.4	34.0	65.1
Ceylon	92.8	23.0[2/]	-	57.0

1/ Food balances in foreign countries (2). 2/ Largely imported.

Rice is the cereal of the Far East and average diets obtain between 55 and 80 percent of their calories from cereals (Table 3).

Consumption of protein-rich and protein-poor foods. The protein deficiency problem has often been stressed as the major nutrition problem in developing countries. Some generalizations can be made relating protein deficiency to geographical regions and to dietary patterns. All countries with less than 60 grams of protein per person per day are in the tropics (except Libya and Pakistan). No countries using wheat as the sole cereal fall below this arbitrary cut-off point in protein consumption. According to the compilation in The World Food Budget (4, 1961), in the Far East the low-protein countries are Burma, Indonesia, Malaya, the Philippines and Thailand. The sub-continent of India also falls into this category.

Table 3. Consumption of cereals in Far Eastern countries[1/]

	kg./caput/year				Percent of calories from cereals
	Rice	Wheat[2/]	Corn	Other cereals	
Thailand	144.0	1.2	1.0	-	65.9
Burma	160.7	1.4	0.7	3.3	76.0
Malaya	126.5	18.8	0.3	1.1	63.3
Indonesia	90.4	1.1	29.4	-	55.8
Philippines	91.1	11.7	27.5	0.8	60.3
Taiwan	132.6	18.8	0.5	0.4	64.5
South Korea	97.7	19.0	-	49.6[3/]	79.7
Japan	115.6	25.5	-	15.2[3/]	66.7

1/ Food balances in foreign countries (2). 2/ Largely imported. 3/ Mostly barley.

Since protein malnutrition is most acute in countries where cereals other than wheat are consumed, it is of interest to compare wheat, rice, and corn with respect to protein composition. These three cereals differ markedly, not only in protein content (rice 7 percent, corn 9 percent, and wheat 12 percent), but also in the biological value of their protein (rice 72, wheat 59, and corn 42). On a comparative basis, if all the protein in the diet came from one of the cereals, and if biological value were taken into account, the minimum daily requirement would be in the proportion of 44 grams of protein from rice, 53 grams of protein from wheat, and 75 grams of protein from corn. If the entire calorie requirements were supplied by a cereal, wheat alone would provide more than the minimum amount of protein needed; rice would come close and corn would fall far short. The protein accompanying a 2,000 calorie intake of each of the cereals is 72 grams for wheat, 48 grams for corn, and 39 grams for rice (Table 4).

Table 4. Comparison of protein in rice, corn, and wheat[1/]

	Rice	Corn	Wheat
Protein content (g./100 g.)	7	9	12
Estimated protein score (biological value)	72	42	59
Daily requirement in grams of protein	44	75	53
Protein accompanying 2000 calorie intake	39	48	72

1/ Sebrell and Hand (10).

It is evident that wheat diets do not require protein supplementation except insofar as other low-protein foods are included. However, all rice and corn diets require supplementation with high-protein foods. The need for protein supplementation is most urgent for growing children. The protein content of a diet is dependent on the choice of cereal and other foods high or low in protein (Tables 5 and 6).

In general, Far Eastern diets are characterized by low quantities of animal products such as meats, fish, eggs, and milk. In the Far East, Indonesia is the only country that makes a large use of cassava and other yams. There is no geographical pattern in the consumption of pulses which are consumed in all developing countries in average amounts supplying from 2 to 12 percent of total food calories. There is also no correlation between the level of pulse consumption and the availability of protein in the national food balances. There are marked regional variations in the

consumption of sugar. The lowest consumption is in the range of 6 to 16 kg. per person per year in the Far East. In the Near East the range is 13 to 19 (except for Israel). High consumption of sugar is a nutritional handicap in countries where the supply of protein is low.

Table 5. Protein-calorie ratio of selected low-protein foods (edible portion)[1/]

	Grams protein per 1000 calories
Wheat	29
Corn	24
Rice	19
White potatoes	24
White sweet potatoes	15
Plantain	17
Cassava	8
Coconut	9
Dates	8

1/ Agricultural Handbook No. 34 (1).

Table 6. Protein-calorie ratio of selected supplemental foods[1/]

	Grams protein per 1000 calories
Codfish	219
Sardines	121
Soy beans	105
Lean beef	92
Eggs	80
Dry beans	68
Cow's milk	56
Peanuts	48
Lean pork	37

1/ Agricultural Handbook (1).

Consumption of fats and oils in the underdeveloped areas of the world is much lower than in Western Europe with no very pronounced differences between regions. Although ranges overlap, average figures would put the Far East at the lowest level of fat consumption (see Tables 7,8,9).

Table 7. Consumption of selected protein-poor and protein-rich foods in Near Eastern countries[1/]

	kg./caput/year				
	Sugar	Potatoes	Pulses	Meat	Fish
Iran	16	-	7	17	1
Iraq	19	-	10	16	3
Israel	29	41	4	26	12
Jordan	14	-	15	10	1
Lebanon	17	19	5	19	2
Syria	13	6	6	17	1
Turkey	13	42	9	14	4

1/ Food balances in foreign countries (2).

Table 8. Consumption of protein-poor and protein-rich foods in the Middle East[1/]

	kg./caput/year						
	Sugar	Potatoes	Cassava	Coconut	Pulses	Meat	Fish
Pakistan	18.6	5.6[2/]	-	-	12.8	6.7	8.4
India	12.7	5.5	4.5	3.2	23.1	1.4	6.1
Ceylon	11.0	8.4	22.4	31.8	6.9	4.9	18.1

1/ Food balances in foreign countries (2). 2/ Roots and tubers.

Table 9. Consumption of selected protein-poor and protein-rich foods[1/] in Far Eastern countries

	kg./caput/year								
	Sugar	Potatoes[2/]	Cassava	Other Roots	Bananas	Coconuts	Pulses	Meat	Fish
Burma	10	2	-	-	-	-	10	4	26
Thailand	8	4	-	1	-	16	6	10	27
Malaya	16	15	-	2	43	4	7	9	19
Indonesia	11	33	20	92	-	7	12	2	9
Philippines	13	33	11	-	-	8	8	10	24
Taiwan	13	71	1	2	-	-	13	19	22
South Korea	7	53	-	-	-	-	8	6	33
Japan	15	79	-	-	-	-	13[3/]	4	40

1/ Food balances in foreign countries (2). 2/ White potatoes and sweet potatoes. 3/ Including soybean cake.

Food consumption patterns from dietary surveys. Food balance tables give valuable information on food consumption patterns in countries where the dietary practices are relatively uniform provided, of course, that the statistics are accurate. This last condition is rarely fulfilled, and many of the figures in some food balance tables are no better than educated guesses. For some countries, as for South Vietnam, no food balance tables are available.

In countries of diverse dietary habits, food balance tables may give a misleading picture of food consumption patterns. Diversity results when ethnic groups have differing food preferences or when more than one religion is adhered to or when the population is sharply stratified along economic lines. Variations in climate caused by differences in latitude, altitude, and rainfall will influence the choice of crops and consequently the food consumption pattern.

In all large countries this diversity is the rule rather than the exception and useful information on food patterns cannot be obtained from food balance tables. For example, the food balance table for Pakistan shows consumptions of rice and wheat that are about equal, yet almost all the rice is eaten in East Pakistan and almost all the wheat is eaten in West Pakistan.

In order to make practical recommendations for nutritional improvement, it is necessary to know in detail the food consumption pattern of the important population segments. This information can only be obtained from dietary surveys. The methods used in making dietary surveys of civilian groups have been described by Combs and Wolf (7). In the past, the tediousness of making dietary surveys has tended to discourage this work. The methods have now been simplified and shown to be reliable. Recognizing that the ICNND surveys have been conducted over short periods, it is a matter of great importance that a sufficient number of dietary surveys be made in every country in which nutritional status is being assessed. These should be conducted by the countries themselves at different seasons and should include all critical population segments.

Relation of the nutrient composition of diets to the appraisal of nutritional status. The nutritional status of the individual and of population groups has been appraised by evaluation of the combined results of dietary surveys (Table 10), determination of the nutrient composition of the diets (Table 11), biochemical studies (Table 12), and clinical examinations. Generally, biochemical studies have consisted of hematologic tests on whole blood, measurement of the serum concentrations of vitamin A, carotene, vitamin C, serum protein, and protein fractions, and determination of the urinary excretion of thiamine, riboflavin, and niacin. The nutrient composition of diets has been determined by calculation of intakes from standard food tables as well as by chemical analysis of food composites (Table 11). Estimation of adequacy is based upon a suggested guide for interpreting dietary data (6).

Table 10. Diet patterns obtained from dietary surveys[1/]
(grams per person per day)

	Lebanon	Thailand
Wheat	387	-
Rice	-	440.2
Sugar	26	0.2
Meats, poultry, eggs and fish	60	74.9
Milk and milk products	157	-
Leafy, green and yellow vegetables	114	14.4
Pulses	30	-

1/ Data obtained by use of dietary questionnaire.

Table 11. Average nutrient intake in civilian diets[1/]
(per person per day)

	Calories	Protein gm.	Vitamin A I.U.	Thiamine mg.	Riboflavin mg.	Vitamin C mg.
Lebanon	2312	73	3843	0.79	1.11	63
Thailand	1770	47.2	2963	0.42	0.50	26

1/ Values obtained by questionnaires and chemical analyses.

Table 12. Biochemical findings among civilians--percent "deficient" + "low"[1/]

	Lebanon	Thailand
Serum vitamin A	15.9	37.5
Serum vitamin C	7.4	3.4
Thiamine excretion	0	62.0
Riboflavin excretion[2/]	58.5	92.5

1/ According to biochemical standards of the ICNND. 2/ Adults only.

There is an urgent need for more complete and more accurate food composition tables. In order to fill this need in one region, the Interdepartmental Committee on Nutrition for National Defense has cooperated with the Institute for Nutrition in Central America and Panama in the preparation of a food composition table for use in Latin America (3). It is hoped that this work can be extended to other regions.

Although the correlations among the clinical, biochemical, and dietary evidence of deficiencies are by no means perfect, the most valid picture can be derived from simultaneously examining all three approaches. The limitations of such correlations have been discussed by Plough and Bridgforth (8).

If the intake of a vitamin for a population group is low or marginal as determined by analyses of representative diets, it can be concluded safely that many individuals in this group are receiving deficient amounts of the vitamin. It must be recalled that, in a survey type of undertaking, the clinical and biochemical data are obtained from single individuals, but the dietary data represent an average of groups of people.

The nutrition problems most frequently encountered are low or marginal intakes of thiamin, riboflavin, vitamin A and vitamin C, protein malnutrition and iodine deficiency. Low thiamin intakes are usually associated with the use of polished rice and refined wheat flour. Adequate riboflavin is difficult to provide in diets low in animal products. Both of these problems can be remedied at low cost by enrichment of rice and wheat flour. Vitamins A and C can be provided in adequate amounts by increasing the consumption of certain fresh fruits and vegetables. The solution of protein malnutrition lies in developing a number of sources of well-balanced protein which need not be of animal origin.

The degrees of iodine malnutrition have been assessed by measurement of the urinary excretion of stable iodine and determination of 24-hour uptake of labeled iodine by the thyroid gland in persons with and without goiter, along with clinical examination for goiter. Iodine deficiency and goiter are widely distributed in many countries, occurring in all age groups and both sexes, the most susceptible being the school age child and pregnant and nursing women. Iodization of salt is the most practical solution, if this can be done where salt is produced, refined, or transshipped.

Blood analyses for hemoglobin have indicated wide prevalence of anemia, but dietary data have often revealed iron intakes considered to be normal in Western countries. Establishment of the exact cause of many of the anemias is not a simple matter and the occurrence of low hemoglobin levels is not a sufficient criterion for the diagnosis of iron deficiency. The problem is further complicated by the need to determine the true iron requirements in the presence of endemic parasitism, by the variability of iron availability in different food items, and the effect of various physiological conditions on iron absorption. Altitude and race must also be considered in evaluating the degree of anemia.

Data from the dietary appraisal represent food and nutrients consumed at the time of the survey. Additional data is needed to reflect seasonal variations. For the development of practical recommendations and programs which enable maximum utilization of local resources, dietary intake, food habits, production, and processing are of paramount importance. Other information is useful such as the price of foods and the percent of income spent on food.

In accordance with the established criteria, it is evident that nutrition problems exist in all the countries surveyed by ICNND (Table 13).

Table 13. Presence of nutrition problems revealed by ICNND surveys in Asian countries

A: General nutrition problem. B: Problem in specific areas of country or in special groups. C: Evidence manifested by clinical or dietary or biochemical results in special areas or groups.

	Calorie deficit	Protein	Vitamin A	Vitamin C	Thiamine	Riboflavin
Lebanon	B	C	B			A
Vietnam	-	C	B	C	A	A
Thailand	-	C	B	C	A	A

Conclusions. ICNND surveys in 21 countries have made clear the need for greater emphasis on nutrition. Programs in nutrition education for mothers attending maternal and child health and other clinics, for teachers in the schools, for those who work in health fields, in home economics and in agriculture have been outlined and strongly recommended by the Committee throughout these regions. This includes training of nutrition workers, wherever possible making use of existing local educational institutions. Instruction in home gardening and in practical methods of home preservation of foods have been urged.

Recommendations for expansion of the food supply are related to development and improvement of agricultural production and industrial food processing, and the storage, distribution, and marketing of foods. An important contribution of food technology to nutritional status can be obtained by the development of protein supplements in forms that are inexpensive and acceptable. In all developing countries there is a need for establishing food science laboratories in view of the key role of food science in the following broad fields:

1. In agriculture by providing improved outlets for farm products, extending the consumption of these products from the harvest season to a year-around basis, and preventing waste and spoilage of temporary crop surpluses.
2. In industry by providing employment through an expansion of food processing and by developing products for export.
3. In public health by improving the nutritional value of foods and sanitary practices in food handling.

An effective food science laboratory should contain specialists in engineering, food analysis, bacteriology, and nutrition. The laboratory should be equipped with a pilot plant to allow developmental work on a semicommercial scale.

If the full, potential benefits of our Food for Peace program are to be achieved, the local currencies obtained from the sale of food surpluses must be used to strengthen the health and economy of the recipient countries. First priority should be given to measures that will help these countries help themselves in solving their food problems. The establishment of centers for research on foods and nutrition is essential. Public Law 480 funds are available in many countries and their use for research and health purposes is permitted under Section 104k.

Discussion. Questions were concerned with the desirable protein content for wheat for export to various countries, protein content of millets and sorghums, period of the surveys, criteria for biological value of proteins, and potentialities of fish products. Related discussion was as follows:

Although the white wheat at about 8 percent protein may be preferred in India, where it is made into chapatis, a harder, higher protein wheat is favored in Lebanon and other Middle Eastern countries. The 12 percent protein level was that found in Lebanese wheats. Nutritionally, wheat of 10 percent protein would not be too far from that at 12 percent, but 8 percent protein wheat would begin to be not so desirable. The comment was made that exported wheat bulgur from white wheat has been about 8-1/2 percent protein, and that from red wheat, 10-1/2 to 11 percent protein.

Millet and sorghum protein values vary greatly. Some are excellent sources. Values for millet were stated as usually at 8 to 9 percent, with some as high as 25 percent.

The surveys were made beginning about 1956, the Committee having been organized in 1955. It is difficult to generalize about the food habits in any country. Few countries are so small that there are no marked differences from one end to the other.

Biological values of proteins were taken from literature value, chiefly from rat-feeding tests. These were relatively old tables, based on the Mitchell tests, and their absolute accuracy cannot be vouched for. There is considerable variation in the literature.

Fish products should be used if possible. However, it is not always possible to get fish products where they are needed, and they would not be adequate to supply all of Asia's needs.

BIBLIOGRAPHY

1. Composition of Foods Used in Far Eastern Countries. U. S. Dept. Agr. Handbook 34, Washington, D. C., 1952.

2. Food Balances in Foreign Countries. Part 1. Estimates for 16 Countries of Western Europe, FAS-M-100, Oct. 1960; Part 2. Estimates for 12 Countries in the Far East, FAS-M-101, Oct. 1960; Part 3. Estimates for 20 Republics of Latin America, FAS-M-104, Nov. 1960; Part 4. Estimates for 28 Countries of Africa and Western Asia, FAS-M-108, Feb. 1961. U. S. Foreign Agr. Serv., Washington, D. C.

3. Food Composition Table for Use in Latin America. Inst. of Nutr. of Cent. Amer. and Panama and Interdepartmental Committee on Nutr. for Natl. Defense, June 1961.

4. The World Food Budget, 1962 and 1966. U. S. Foreign Agr. Econ. Rpt. 4, Washington, D. C., Oct. 1961.

5. Manual of Nutrition Surveys. Interdepartmental Committee on Nutr. for Natl. Defense, May 1957, Washington, D. C.

6. Suggested Guide for Interpreting Dietary and Biochemical Data. Interdepartmental Committee on Nutr. for Natl. Defense, U. S. Pub. Health Rpt. 75:687, 1960.

7. Combs, G. F., and Wolf, A. C. Methods Used in the Dietary Survey of Civilians in Ecuador, U. S. Pub. Health Rpt. 75:707-717, 1960.

8. Plough, I. C., and Bridgforth, E. B. Relations of Clinical and Dietary Findings in Nutrition Surveys, U. S. Pub. Health Rpt. 75:699, 1960.

9. Schaefer, A. E., and Berry, F. B. U. S. Interest in World Nutrition, U. S. Pub. Health Rpt. 75:677, 1960.

10. Sebrell, W. H., Jr., and Hand, D. B. Protein Malnutrition as a World Problem. Amino Acid Malnutrition, XIII Annual Protein Conf. 1957.

OBSERVATIONS ON THE NUTRITIONAL DEFICIENCIES, FOOD TRADITIONS, SUPPLY, AND NEEDS IN LATIN AMERICA
(INCAP Publication I-248)

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The tremendous advances in all phases of communication during the past fifty years have brought even the remotest areas of the world into the community of nations and, consequently, within the sphere of the world's interest and concern. Ignorance of the activities in these regions can no longer be pleaded as a reason for inaction regarding their pressing problems. Today, we all have an obligation to become familar with the status of the world's populations and to take some kind of action to bring to those in dire need the means whereby they can ultimately take care of themselves. Not the least of the many problems and probably the most important is the problem of undernourishment and malnutrition which results in vast numbers of unnecessary deaths and so undermines those who survive as to make them only partially effective. The work of solving the problems of malnutrition has been going on, of course, for a long time, but it has been confined to a relatively small group of people.

There is need for a more comprehensive understanding of the preeminent importance of this problem. There must first be an understanding of the conditions under which the peoples in underdeveloped areas are struggling; then there must be positive action in attacking and improving these conditions. More than half of the western hemisphere--the entire Latin America area--is in the category of "underdeveloped areas." It is to give some information about the nutritional deficiencies of these countries, to indicate the role which tradition plays in relation to some of the nutritional problems here found, and to discuss the supplies of foods and the unfulfilled nutritional needs of the populations of Latin America that this paper has been prepared.

Latin American populations. The Latin American population is distributed among twenty countries located from Mexico to Argentina and Chile. The topography is very complex, with mountain ranges that divide the countries into plateaus having relatively temperate and uniform climates and lowlands with tropical or semi-tropical conditions.

Ethnically, the population is American Indian in origin, but, as a result of the Spanish conquest, most of it is now of mixed Indian-Spanish descent, except for Brazil where there is a mixture of cultures, ranging from that of negroid peoples to the dominating Portuguese. Throughout the area, the Iberian influence still survives in the language, religion, and social structure, so that basically the populations of the 20 countries have many similar characteristics. The populations are predominantly rural, and the urban concentrations are confined to only one or two large cities in each country. Although some of the rural populations are influenced culturally, socially, and economically by the urban populations and thus are in a somewhat improved condition, the majority in many countries have low social and economic status, and illiteracy runs as high as 70 percent in a few countries. Seven out of ten persons living in the rural areas obtain their food and livelihood from agriculture, and until five to ten years ago, technology was almost non-existent in most Latin American countries.

According to recent estimates, the population of Latin America totals 198,147,000 for the twenty countries (Table 1). Brazil, Mexico, and Argentina have the largest populations, although countries such as El Salvador, Haiti, Dominican Republic, Cuba, and Guatemala, in that order, show the largest population densities (3). Just as the world's population is increasing, so is that of Latin America; in 1951, it had 159,162,000 people. By 1955 it had increased to 175,061,000 and from 1955

to 1960, the increase amounted to 23,086,000. Because of improved medical care, public health programs, and greater food consumption, these increases are expected to continue. Probably the most pressing problem is how to feed the already large population of today and the potentially greater one of tomorrow, when advances in agriculture and other phases of food production are not only painfully slow in some areas but are actually neglected in most others.

Table 1. Latin American population according to recent extimations and population density[1/]

Nation	Population (10^6)	Density pop./km^2	Nation	Population (10^6)	Density pop./km^2
Argentina	20.959	8	Haiti	3.505	126
Bolivia	3.462	3	Honduras	1.950	17
Brazil	65.743	8	Mexico	34.626	18
Colombia	14.132	12	Nicaragua	1.471	10
Costa Rica	1.150	23	Panama	1.053	14
Cuba	6.744	59	Paraguay	1.768	4
Chile	7.551	10	Peru	10.857	8
Ecuador	4.298	16	Rep. Dominicana	2.994	62
El Salvador	2.613	122	Uruaguay	2.803	15
Guatemala	3.759	35	Venezuela	6.709	7

1/ Taken from: America en Cifras, Union Panamericana, OEA, 1960.

Before much real progress can be made to correct the conditions which now hamper progress toward a more abundant supply of food, two difficult social problems must be recognized and somehow dealt with. First, there must be better distribution of the land; and second, effective educational programs must be developed and must reach the remote and isolated farmers who are living under incredibly bad conditions. Unfortunately, both these problems are tossed about for political purposes; and consequently, national planning for their solution is practically nonexistent.

Nutritional deficiencies. The first conference on Nutrition Problems in Latin America, held in Montevideo in 1948 (24), found that information concerning diets and dietary habits was available for only a few countries (26,27). Recognizing that such information was basic to further work and that biochemical information, essential to an objective assessment of nutritional status, must be secured as well, the conference recommended that nutritional surveys be made throughout the area.

In Venezuela, the National Institute of Nutrition (5-7, 39) provided biochemical information on diets which indicated that riboflavin, niacin, thiamin, and vitamin A intakes were low, ranging from 50 to 60 percent of the recommended dietary allowances of the National Research Council. Based on these allowances, calcium intake averaged 70 percent, while protein and calorie intakes averaged 79 and 85 percent respectively. Other nutrients were found in adequate amounts. These reports also indicated that economic factors influenced the diet (6).

Clinical surveys in Caracas, Venezuela, revealed signs of vitamin A deficiency in 64 out of 101 school children. Niacin and riboflavin deficiencies were also observed in these children, and their hemoglobin concentration was above normal, while the red cell count was below normal (7,45).

Based on data collected in 1953 in five areas, the National Institute of Nutrition of Ecuador reported deficiencies in calcium, riboflavin, and vitamin A intakes. While the total amount of protein seemed adequate, the proportion of animal protein in the diet was low (42).

Reports from Peru (23) showed that the diets consumed by the Peruvian Indians were low in protein, calcium, iron, riboflavin, vitamin A, and thiamine, and that protein intake was lower than is desirable. Muscular development was frequently found to be poor; clinical signs of vitamin A deficiency were common; and a high prevalence of intestinal parasites was found (2). Other studies indicated that anemias were widespread and were macrocytic and hypochronic. The diets of children on cotton plantations, in fishing villages, and jungle towns were discovered to be low in calcium, vitamin A, riboflavin, protein, and iron; and growth and development studies indicated that these children were below normal for their ages (53,54).

From Colombia, the reports (41,52) indicated that the diet of the well-to-do socio-economic class was adequate, while the food consumption of the lower socio-economic classes was low in both quantity and quality. Fat consumption was high for both groups. The children were found to be both light in weight and short in height, and about 90 percent were affected by iron-deficiency anemia. Similar deficiency signs were also seen in adults. Vitamin A deficiency was common, and pellagra was present in a mild form in the corn-consuming areas of the interior. Beriberi was rare, while riboflavin deficiency, accompanied by angular stomatitis, was common. Vitamin C deficiency was also reported. Other surveys in Colombia suggested that diets were low in calories and calcium (41).

From Chile (49) it was reported that the mean national diet was adequate in protein content as shown by nitrogen balance tests in rats. When this diet, containing 12.8 percent protein, was supplemented with 8.5 or 11.8 percent milk, or when calcium was added in the same proportion as that in 8.5 percent milk, the growth of rats improved. The conclusion was, therefore, that the diet was low in calcium. Further tests indicated low values for iron, thiamin, riboflavin, vitamin A, and niacin.

A report from Bolivia (40) indicated low intakes of calcium, riboflavin, thiamin, and vitamin A, and in some cases evidence was found of deficient intakes of calories, protein, and iron. Diets of workers and their families were in general less adequate than were those consumed by the farm owners and by members of urban households.

Several reports from Brazil revealed iron, calcium, vitamin A, vitamin C, and vitamin B-complex deficiencies as well as protein deficiency evidenced by the common occurrence of kwashiorkor (20-22, 37,55). Because of differences in agricultural production and climatic conditions, some areas of the country appeared to be more affected than others. The diet of northern Brazil was reported (43) to be monotonous and imbalanced, only minor changes having occurred during the last 25 years. Intakes of vitamin A and calcium in all socio-economic classes were generally low because dairy products, vegetables, and fruits are little used.

From Central America, several reports indicated low intakes of protein from animal sources, of riboflavin, and of vitamin A (30-32). Clinical surveys among school children revealed consequent retardation of growth and bone maturation. The widespread occurrence of the "Síndrome Pluricarencial de la Infancia (SPI)" in the area is additional clinicopathological evidence of the serious dietary deficiency of animal proteins, or of other well-balances proteins (4,36,47,51).

Also recognized as a serious public health problem in all of the Latin American countries is the high prevalence, in some communities up to 80 percent of endemic goiter (48). It has been accepted that endemic goiter is produced by a relative iodine deficiency in the diet, although the effect of goitrogenic factors on relative iodine requirements has not been investigated in Latin America. The Third Conference on Nutrition Problems in Latin America (25) recommended that potassium iodate be added to crude salt at levels of one part of iodine to 10,000 to 20,000 parts of salt. It also recommended the enactment of legislation requiring the iodization of salt in all countries where goiter is prevalent.

The most widespread and serious nutritional problem in Latin America (the one that affects half of the children born into the low-income groups) is kwashiorkor. Most deaths from protein malnutrition occur after weaning, and the mortality of children from one to four years old is the best index of the seriousness of this problem (4,47,51). While the mortality of children one to four years of age in the United States and most countries of Western Europe is around 1 per 1000, in four rural Guatemalan towns a mortality rate of 50.3 per 1000 children was found after a careful investigation. Nearly two-fifths of these one to four year olds had died from kwashiorkor, and the remainder had died almost equally from infectious diarrhea and systemic infections. Probably very few of the latter would have died if they had been well nourished (4,47).

Table 2 shows the seriousness of kwashiorkor in areas where this deficiency disease is common as compared with deaths occurring in countries where kwashiorkor is rare or unknown (4,51). Another disease of severe malnutrition in children is marasmus, which develops when the child is deprived not only of adequate protein but also of calories and other nutrients. Table 3 shows the number of children 0 to 4 years of age in the several Latin American countries, a large percentage of whom are exposed to protein, calorie, and vitamin deficiencies and who will continue to lack sufficient food in future years if conditions are not improved (3).

Table 2. Specific mortality rates, per 1000 population, of children 1 to 4 years of age in selected countries, including Latin America (1955-56)[1/]

Countries where kwashiorkor is rare or unknown	Mortality	Countries where kwashiorkor is common	Mortality
Argentina	3.8	Colombia	20.3
Australia	1.3	Ecuador	28.8
Belgium	1.6	Egypt	60.7
Canada	1.5	El Salvador	22.7
France	1.6	Guatemala	42.7
Japan	3.8	Guinea	55.4
Netherlands	1.2	Mexico	24.0
Sweden	1.0	Thailand	14.5
United States	1.1	Venezuela	12.5

1/ Summary of Four-Year Reports on Health Conditions in the Americas. Pan American Sanitary Bureau, Regional Office of the World Health Organization, Scientific Publication No. 40, Washington, D. C., 1958.

Table 3. Latin American population, 0-4 years old[1/]

Nation	Population	Date	Nation	Population	Date
Argentina	1,781,409	1947	Haiti	347,872	1950
Bolivia	425,663	1950	Honduras	215.662	1950
Brazil	8,370,880	1950	Mexico	3,969,991	1950
Colombia	1,873,080	1951	Nicaragua	168,910	1950
Costa Rica	132,635	1950	Panama	122,474	1950
Cuba	737,025	1953	Paraguay	217,640	1950
Chile	779,139	1952	Peru	960,981	1950
Ecuador	533,238	1950	Rep. Dominicana	375,841	1950
El Salvador	289,054	1950	Venezuela	847,748	1950
Guatemala	469,782				

1/ América en Cifras, Unión Panamericana, OEA, 1960.

It has been stated (38) that more than half of the population of Latin America obtain only 65 percent of their caloric requirements; that the protein content of the diets is generally low and of poor quality, and that vitamin deficiencies are commonly associated with these diets. Agricultural, economic, cultural, and sociological factors are causes in the etiology of protein malnutrition.

Food production. Although Latin America is considered by the world's economists as one of the most promising areas for greater food production, little is being done to fulfill this promise. Basically, food production depends upon agricultural practices, even though topography and locality influence its pattern. In much of Latin America, agricultural practices are almost primitive, for most of the cultivation is done either by hand or with the crudest kinds of implements. For a number of years, nevertheless, agricultural production rose steadily; however, during the recent past it has slowed down. In 1953-54, the index for agricultural production was 96; it rose in 1955-56 to 101; rose again in 1958-59 to 114. For 1959-60, however, preliminary estimates indicate that it will be down to 112. If this trend continues, the already serious food situation will deteriorate further, for the annual margin of production over population has been estimated as slightly less than 1 percent in Latin America (35). With increases in population and decreases in agricultural production, a crisis might well develop. Table 4 gives some statistics on agricultural food production in Latin America (3,35).

Table 4. Production of major commodities (million metric tons)[1/]

	Latin America 198,147,000 population	North America[2/] 201,370,000 population
Wheat	9.72	41.96
Maize	21.06	111.57
Rice	4.23	1.57
Sugar	17.04	--
Citrus fruit	4.71	7.33
Bananas	10.50	--
Coffee	3.72	--
Cocoa	0.33	--
Animal fats	--	2.85
Milk	20.20	64.75
Meat	6.75	13.66
Eggs	0.95	4.01

1/ The State of Food and Agriculture, FAO, 1960. 2/ U. S.: 183,285,000; Canada: 18,085,000.

Many Latin American countries, particularly those that are less developed, are trying to increase diversification of their agricultural production both to free themselves of dependence on a very limited range of export crops and to improve the nutritional quality of the diets of their populations. This work is being done very slowly, however, and it will be some time before any effect will be evident.

Although large areas of land are still available, millions of people through-out tropical America are still forced to wrest a living from over-worked farms that become less and less productive as the years pass. Agricultural production is far behind what it should be because of the following reasons: (1) failure to employ modern techniques in relation to soil conservation, soil fertility, forage, food crops, and animal husbandry; (2) failure to use better varieties of plants or breeds of farm animals; (3) high production costs; (4) lack of communication, and in some cases, bad distribution of land.

Many of these problems could be solved if more competent agricultural experiment stations were carrying out the research needed to help the small farmer solve his problems, and if governments paid more attention to agriculture. As it is now, each farmer must carry out his own "agricultural research" which, good or bad, he keeps secret from his competition. Practically all the agricultural experiment stations in this area of the world are situated on the richer lands and devote their efforts to solving the problems of the big producers who can afford to institute new procedures and to buy the equipment necessary for large scale operations. The result is that the producers of the big crops, such as coffee, cotton, sugar, and rubber, upon which the economies of many Latin American countries depend, reap the benefits of agricultural research, while the problems related to producing food for increasing populations, equally important to the well-being of the countries, are scarcely recognized and rarely given attention.

In addition to this very serious lack of assistance, crop losses caused by insects and adverse environmental conditions also have a depressing effect on agricultural production. Furthermore, many small farmers cannot afford to buy the insecticides, herbicides, and fertilizers which could be enormously helpful in increasing their yields. Lack of an overall program of soil conservation, year after year, reduces useful land into waste areas. Farm machinery and the materials to keep the machinery functioning are also far too costly for most farmers, and sometimes machinery which is available cannot be used because the contours of the land and weather conditions are such that the machinery cannot be operated efficiently.

In general, little emphasis is given to successful cultivation of cereal and vegetable crops. In fact production of basic cereal grains and starch roots has expanded more slowly than has total production in Latin America. Table 5 shows 1958 production figures for wheat, rice, and corn. The few efforts with these crops that agricultural stations make seem to be related only to the quantity of yields, whereas the quality of the products should receive at least equal attention.

Table 5. Cereal production (1958) (1000 tons)[1/]

Nation	Wheat	Rice	Corn	Nation	Wheat	Rice	Corn
Argentina	6720	157	4932	Honduras	1	19	261
Bolivia	11	21	100	Mexico	1322	252	5154
Brazil	589[3/]	3829	7737	Nicaragua	--	33	108
Colombia	110[3/]	420	800	Panama	--[2/]	104	80
Costa Rica	--	57	60	Paraguay	3[2/]	16	290
Cuba	--	253	155	Rep. Domincana	--	116	98
Chile	1178	87	130	Peru	150	196	290
Ecuador	39	113	143	Uruguay	525	37	119
El Salvador	--	13	142	Venezuela	3	19	358
Guatemala	22	12	469				

1/ The State of Food and Agriculture, FAO, 1960. 2/ 1955. 3/ 1956.

INCAP, in cooperation with the Rockefeller Foundation and, when possible, with local agricultural organizations, has been actively engaged in studies related to improving the quality of corn and sorghum (10,16). Except for a relatively few studies, little attention has been given to beans. The production figures (3,35) for this food crop are shown in Table 6. Because of its high protein content, more emphasis should be placed on this food because it can complement cereal protein to a large extent; its production is relatively low, and its quality has received little attention. Little is known about the quality of forages in Latin America. Only a few institutions like INCAP have studied forage crops, even though the possibilities of increasing food production by improving forage are tremendous (12,13,50).

Table 6. Dried bean and milk production (1957) (1000 tons)[1/]

Nation	Dried bean	Milk	Nation	Dried bean	Milk
Argentina	23	4662	Honduras	28	--
Brazil	1454	4407	Mexico	410	2750
Colombia	72	2085[2/]	Nicaragua	12	--
Costa Rica	15	76	Panama	4	74
Cuba	17	772	Paraguay	18	130
Chile	91	825[3/]	Peru	27	390
Ecuador	23	360	Rep. Dominicana	18	---
El Salvador	13	--	Uruguay	--	630
Guatemala	24	93	Venezuela	69	378

1/ América en Cifras, Unión Panamericana, OEA, 1960. 2/ 1956. 3/ 1955.

Another area where little has been done is in milk and beef production, although the potentialities of some regions are quite promising. Milk production figures for individual countries (3) are also shown in Table 6. Cattle, both dairy and beef, are now fed mainly on grass because practical and economical feed concentrates are seldom available; and salt mixtures, which in some more advanced countries have resulted in significant increases in milk and beef production, are unknown. Swine production suffers more or less the same disadvantages. Parasitism, both internal and external, decreases animal food production, but very little research has been done to fight this problem. In many countries, however, poultry and egg production has been increasing, even though costly protein concentrates for feeding must be imported. In many instances, the agricultural industry is competing with humans for the cereal grains, with the poor not being compensated because they cannot afford to buy poultry and eggs.

Added to the problems of agricultural production are those of conservation. If losses of stored grains are high for the most advanced countries, it is not hard to realize how enormous they can be in many Latin American countries. Large volumes of milk are produced in many areas, for example, but because of poor sanitation, lack of storage facilities, high temperatures, inadequate and costly transportation, milk either cannot be distributed properly or the cost of its distribution is so high that most rural and many urban populations cannot afford to buy it.

Food technology is little known in many areas of Latin America, and although some foods are processed, there is little or no understanding of quality control. In many instances processors of agricultural crops, such as oil seeds and others, do not know or care about the benefits which could be obtained from controlled operation. Only slowly are plant and product control coming into use.

The Latin American countries are rich sources of new crops for either food or industrial purposes. The potentialities of the whole area are tremendous, but they are not being efficiently utilized because no real chemical or biological knowledge about them is available. Urgently needed are research and personnel trained in agriculture, chemistry, and other sciences so that the area's resources can be utilized and food production can be significantly increased.

Because of the inefficient production of agricultural crops and animal products, the lack of agricultural and technological knowledge, the poor preservation, and the poor and costly transportation, the cost per unit of many good quality foods becomes so high that large groups of people cannot afford them.

Food supply, consumption, and habits. Latin America presents a varied picture of food habits; even within relatively short distances great differences exist in food consumption, preparation, preservation, and distribution. Recent dietary surveys show

that European foods have added greatly to the variety of diets in Latin America; however, the native diets still exist, and sometimes they have proved to be of better nutritive value than are the new diets. In some communities the poorer families show a nutritionally superior diet; the wealthier have been drawn away from the better balanced Indian diet by the urban habit of consuming sweets, wheat bread, and fats. Examination of food habit changes in Latin America has indicated that these have changed less rapidly than have other aspects of the culture; and when they occur it is because of a more profound change in the entire social structure. The addition of wheat bread, milk, eggs, and greater quantities of meat to the Latin American diet is a part of urbanization, and the motives leading to their acceptance have little to do with better nutrition (1).

As mentioned earlier, food production is fundamental in the etiology of malnutrition, particularly that of protein, and is a very important factor in determining food availability. Table 7 gives some statistics on food supplies for human consumption in selected countries in Latin America (35,36). It is evident that cereal grains, starchy foods, and sugar are somewhat more available in all the countries, while meat and other animal products are less available in the majority. Dried beans which could effectively complement the cereal grains are in very short supply. INCAP studies have found that the most satisfactory complementation of cereal and bean protein was achieved when each of these foods provided 50 percent of the protein in the mixture (17). Table 8 shows average food consumption per person per day in rural and urban areas of Central America. The striking differences in the rural diet of Guatemala, as compared with the diets of the other countries, are due to the fact that the Guatemalan rural population is mainly Indian and the urban is Mestizo. In Honduras, Nicaragua and Costa Rica, the availability of milk is greater, and the consumption of dairy products is therefore higher (29). In general, animal food products are consumed in lower quantities and starchy foods and cereals in larger quantities in the rural areas. When consumption of cereals in Central American urban and rural areas was estimated, it was found that wheat products were used more as the areas moved from rural to urban. Consequently, as urbanization increases in these countries, there will be a continuous increment in the consumption of wheat products.

Table 7. Food supplies available for human consumption in selected countries (kg./caput/year)[1/]

	Cereals	Starchy foods	Sugar	Dried beans	Vegetables	Fruit	Meat	Eggs	Fish	Milk	Fats
Argentina	104	75	33	2	41	81	118	9	4	140	13
Brazil	90	73	33	26	25	114	29	5	2	58	65
Chile	125	64	33	13	56	31	30	5	31	92	7
Colombia	75	63	51	5	18	55	35	2	2	73	5
Ecuador	78	61	25	12	23	275	11	3	2	76	4
Mexico	156	8	27	17	19	61	12	7	2	78	9
Paraguay	81	260	16	14	-	159	49	-	-	73	13
Uruguay	105	46	37	1	35	55	123	7	1	182	18
Venezuela	81	82	33	15	10	39	25	6	15	120	10

1/ Bengoa and Saldivia, Arch. Venezol. Nutric., 2:327, 357, 1951.

Table 8. Average food consumption (grams/person/day) in rural and urban areas of Central America[1/]

Food groups[2/]	Guatemala		El Salvador		Honduras		Nicaragua		Costa Rica		Panama	
	R	U	R	U	R	U	R	U	R	U	R	U
	(R = rural. U = urban.)											
Dairy[3/]	10	129	46	118	136	231	316	378	114	200	47	75
Eggs	4	6	5	21	5	4	4	2	4	6	8	1
Meats, fish	34	45	21	66	49	59	32	71	20	50	83	87
Pulses	58	64	60	48	56	47	85	45	64	68	54	20
Vegetables	61	46	32	82	127	82	214	31	82	82	6	30
Fruits	23	33	1	34	30	33	8	16	49	22	36	26
Musaceaes	2	16	27	44	18	24	16	58	51	52	36	67
Starchy roots	5	9	5	14	9	32	7	15	24	80	35	29
Cereals	494	290	326	244	367	264	182	231	250	240	189	183
Sugars	47	40	32	32	40	33	33	54	122	112	53	43
Fats	1	7	6	23	5	21	12	22	7	35	35	26

1/Flores, M. In: Tradition Science and Practice in Dietetics. Proc. of the 3rd International Congress of Dietics. London 10-14, July 1961. Yorkshire, Great Britain, Wm. Byles and Sons, Ltd. of Bradford, 1961, p. 23-27. 2/ Amounts of edible portions. 3/ In terms of liquid milk.

Eating habits and economic factors influence food consumption. Each cultural group has its own food preferences and sources and its own methods of preparation. In Mexico and most of the Central American countries, for example, corn, consumed in large quantities, is prepared in the form of tortillas and gruels (15). The people of Colombia eat corn with the germ, and Venezuelans eat it without the germ. In Panama, rice is the most important cereal, while in Uruguay, Chile, and Argentina, wheat is consumed in large quantities (36). Table 9 shows the production and consumption of wheat and corn in several countries in South America (33). In some countries like Peru, Venezuela and Brazil, corn provides more calories and protein than wheat. In general, in the countries where wheat production is low, its consumption is also low, due to the fact that the prices of wheat products are higher than the people can afford to pay. In Venezuela, for example, the use of wheat plus rice for bread-making is encouraged because of the relatively large amount of rice and the high cost of wheat. To sell the idea of this combination, it is advertised that wheat-rice has (a) a higher protein-efficiency ratio, (b) better flavor and texture, (c) longer shelf life, and (d) that it helps the economy of rice producing countries by saving domestic capital by reducing wheat imports. In some countries to save domestic capital, bread is made from a mixture of locally available roots or starch and wheat flour (44).

Table 9. Calorie and protein intake (grams/day) from wheat and corn in selected countries[1/]

Country	Production		Per capita consumption		Calories/day		Protein g./day	
	Wheat	Corn	Wheat	Corn	Wheat	Corn	Wheat	Corn
Argentina[2/]	7690	2546	295.5	13.2	1076	47	32.2	1.3
Chile[3/]	916	69	344.5	--	1254	-	37.6	-
Brazil[3/]	424	6218	62.9	95.6	220	344	7.4	8.9
Peru[4/]	127	612	64.6	181.8	235	647	7.0	17.3
Uruguay[5/]	818.6	212.2	240.1	8.8	874	52	26.2	0.7
Venezuela[6/]	4.2	312.9	70.6	138.5	257	499	7.7	12.9

1/ FAO, Food Balance Sheets, Rome, 1955. 2/ 1955 3/ 1952 4/ 1947. 5/ 1954. 6/ 1951.

Table 10 shows the average consumption of corn and wheat in the Central American countries (28). Consumption of corn outweighs that of wheat in all the countries shown. In some rural towns in Guatemala, corn consumption per person per day has been found to provide up to 74 percent of the daily protein intake. The quantities given provide 15 to 34 grams of protein equivalent to 32 to 49 percent of the daily protein intake, which varies from 40 to 66 grams per adult. In all countries, wheat consumption is higher among the urban population. The average consumption of animal protein is relatively low, varying from 7 to 20 grams per person daily (29). These tables indicate that corn, because it is one of the main items of the Indian culture and its production is very cheap, is consumed in place of other more costly cereals.

Table 10. Average consumption of corn and wheat in the Central American countries[1/]

	C O R N			W H E A T					
	Weight gain	% of Total calories	% of Total protein	Consumption Rural	Consumption Urban	% of Total calories Rural g.	% of Total calories Urban	% of Total protein Rural	% of Total protein Urban
Costa Rica	185	34	32	25	59	5	10	7	12
Nicaragua	300	57	40	20	44	4	9	4	8
Honduras	398	69	48	6	49	1	10	1	10
El Salvador	374	65	58	5	40	1	8	1	8
Guatemala	423	64	49	56	140	10	20	10	19
Panama	---	--	--	23	46	4	10	5	10

1/ Data kindly supplied by Miss Marina Flores.

In the tropical lowland areas of Central and South America, starchy roots and plantains provide a considerable proportion of the total calories. In some areas of Brazil and in Paraguay, manioc is a staple food of major importance. In the Andean highlands, potatoes are consumed in large quantities. Such differences in food consumption indicate that problems of nutrition and measures for their solutions vary from one part of Latin America to another.

The protein sources and quantities available in various countries (36) are shown in Table 11. Total protein consumption in grams per person per day varies from 105 for Argentina to 38.3 for the Dominican Republic. With the exception of a few countries, such as Argentina and Uruguay, the largest percentage of the protein is derived from cereals, while eggs, fish, and milk make relatively low contributions. Countries such as Colombia, Ecuador, and Paraguay have total protein intakes of 48, 51 and 66 g./day, respectively; however, only 22, 13 and 27 grams are from animal sources.

Variations in caloric and nutrient intake between rural and urban populations in Central America (29) are shown in Table 12. In general, the rural areas consume more calories and the urban areas more protein, but this is low for both groups. Animal protein consumption is higher among urban groups. Both calcium and vitamin A intake are highest in rural Guatemala because of the high consumption (15,29) of yellow corn tortillas and of native leaves and vegetables. In spite of the long coastline which should offer great possibilities, the supply of fish in Latin America is meager. Fish is mainly consumed in the coastal areas; inland, as dietary surveys have shown, its consumption is almost negligible. In some countries fishing industries largely for export have been established, but these do not contribute substantially to local fish consumption. At present, people of low economic status cannot afford to buy fish, though these are the people who need it most.

Table 11. Calories and protein supplies of various countries and their sources[1/]

Country	Calories g./head per day	Protein g./head per day	Cereals g./head per day	Cereals %	Pulses g./head per day	Pulses %	Meat g./head per day	Meat %	Eggs g./head per day	Eggs %	Milk g./head per day	Milk %	Total animal g./head per day	Total animal %
Argentina	3020	105	35.0	33.5	2.2	2.1	43.2	41.3	2.0	1.9	14.7	14.1	60.7	58.0
Uruguay	3110	92	28.4	31.0	1.1	1.2	38.1	41.6	2.0	2.2	16.6	18.1	57.2	62.4
Brazil	2500	57	22.1	38.6	13.7	24.0	10.8	18.9	1.0	1.7	2.9	5.1	16.1	28.1
Chile	2450	77	39.6	51.2	5.5	7.1	12.3	15.9	1.4	1.8	7.9	10.2	26.5	34.2
Venezuela	2120	59	22.6	38.3	10.0	16.9	6.8	11.5	0.7	1.2	2.2	3.7	21.0	35.6
Peru	--	54	27.1	49.8	5.4	9.9	7.1	13.1	0.8	1.5	3.0	5.5	12.2	22.4
Mexico	2560	65	39.4	60.7	8.1	12.5	7.3	11.2	0.6	0.9	6.4	9.9	15.2	23.4
Dominican Republic	--	38	13.3	34.7	9.9	25.8	5.5	8.9	0.4	1.0	2.2	5.7	6.4	16.7

1/ Fourth Conference on Nutrition in Latin America, FAO, Guatemala City, 1957.

Table 12. Intake/person/day of calories and nutrients in rural and urban areas of Central America[1/]

Nutrients	Guatemala		El Salvador		Honduras		Nicaragua		Costa Rica		Panama	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Calories	2,243	1,727	1,666	1,723	1,964	1,740	1,623	1,843	1,822	2,049	1,927	1,454
Total protein, g.	66	53	48	52	59	54	55	60	40	53	55	44
Animal protein, %	11	24	12	35	24	35	31	45	20	30	36	50
Calcium, mg.	1,320	787	782	664	846	732	701	750	480	554	200	200
Vitamin A, I.U.	2,273	1,300	547	2,110	1,447	3,530	1,493	1,337	977	1,480	438	338
Nicotinic acid, mg.	12.2	8.8	8.4	10.0	11.1	9.7	9.5	9.3	6.9	10.1	10.2	9.8

1/ Taken from: Flores, M. In Tradition Science and Practice in Dietetics. Proc. of the 3rd International Congress of Dietetics, London 10-14 July 1961, Yorkshire, Great Britain, Wm. Byles and Sons, Ltd., of Bradford, 1961, p. 23-27.

In general, food supplies in Latin America are variable, being highest in cereal grains and lowest in the better quality animal products. Consumption of wheat predominates in urban populations, and rural people eat it only sporadically because it is too expensive. For many populations in Latin America, eating bread is a mark of increased social status; furthermore, they like bread. Bread made of the refined flour in common use, however, does not give them the nutrients they need. Frankly, as far as the nutritional status of the people is concerned, very little would be gained if wheat products were to replace the cereals already in use, unless they were properly enriched and made available at a cost within the reach of the low-income consumers.

The principal objective in practical nutrition programs is to provide a well-balanced diet consisting of suitable food combinations. Commonly-used staple foods which do not provide such a diet must therefore be enriched with individual nutrients or with preparations of high nutritive value. Enrichment of staple cereals with vitamins and other nutrients is already being done in some countries in Latin America. In Chile, El Salvador, and Guatemala, the enrichment of wheat flour with vitamins and minerals is required by law, and similar steps are contemplated in Costa Rica, Nicaragua and Paraguay (36). In Colombia and Panama enrichment of rice is under consideration, and in Venezuela it is already on sale. The enrichment of wheat flour by fish flour is being studied in Chile, Colombia, and Peru; and in Colombia attention is also being given to the use of soy flour for this purpose. Tortilla enrichment has been studied by INCAP (14,18); and in El Salvador tortilla flour is being enriched with fish flour and vitamin A. In Peru and Colombia, the enrichment of wheat flour with synthetic lysine has also been considered, but it has been not recommended as a practical measure (36).

Nutritive value of wheat protein. Many reports in the literature of experiments carried out in animals (46) and humans (19) indicate that wheat flour protein is deficient in the essential amino acid, lysine. As part of an evaluation program of cereal protein for human feeding and as a further test of the applicability of the FAO amino acid reference pattern (34), INCAP has done nitrogen balance studies in young children to determine the effect of amino acid supplementation of wheat flour (19). Representative results from these studies are shown in Figure 1. The basal wheat diets contained: wheat flour 85 g., wheat gluten 7 g., glycine 3 g., and cornstarch 5 g. with a vitamin and mineral capsule given daily. The amino acid supplements were substituted for the 5 percent cornstarch, and the nitrogen from these amino acids replaced glycine nitrogen so that all diets remained isocaloric and isonitrogenous. The children were fed at a rate of 2 g. of protein/kg./day with caloric intakes of 80 to 100/kg./day, according to the estimated requirement of each child. Caloric intake was adjusted with hydrogenated vegetable fat.

The nitrogen balance data as well as the results of other tests indicate that the nutritive value of wheat protein can be improved markedly by the addition of lysine alone to the wheat diet; in some cases, as shown in Figure 2, addition of this supplement gives retentions of nitrogen approximating those obtained if tryptophan and other limiting amino acids are added to comply with the FAO reference levels (34).

These findings are, of course, of great practical importance and should be seriously considered when new foods are introduced to groups of people who already consume diets both qualitatively and quantitatively poor in protein. Every effort should be made to enrich such new foods either by adding the missing nutrients themselves or by adding small amounts of other proteins containing relatively large amounts of the limiting nutrient. INCAP has already initiated efforts along these lines for lime-treated corn flour (14,18). Representative nitrogen balance results of testing the enrichment of lime-treated corn flour with torula yeast and skim milk are shown in Figure 3. As indicated by the increase in nitrogen retention, a significant improvement in protein quality was obtained from additions of 5.0 percent skim milk

or by adding lysine and tryptophan in amounts equivalent to those found in skim milk. As shown in Table 13, similar results have been observed with fish flour and torula yeast. The results show significant increases in nitrogen balance from supplementing lime-treated corn with 5 percent skim milk, 3 percent torula yeast, or 4 percent fish flour.

Table 13. Nitrogen balance of dogs fed lime-treated corn flour enriched with various supplements (average 3 dogs, 8 days/treatment)[1/]

Supplement	N intake mg./kg./day	N absorbed % of intake	N retained % of intake	N retained % of absorbed
None	729	74.9	13.4	17.9
+ 5% skim milk	745	79.2	33.6	42.4
None	675	77.0	19.5	25.4
+ 3% torula yeast	674	77.7	34.7	44.6
None	539	76.1	24.5	32.2
+ 4% fish flour	454	66.1	26.0	39.3

1/ Bressani, R. and Villarreal, E. M. de. Nitrogen balance of dogs fed lime-treated corn supplemented with proteins and amino acids. (In preparation.)

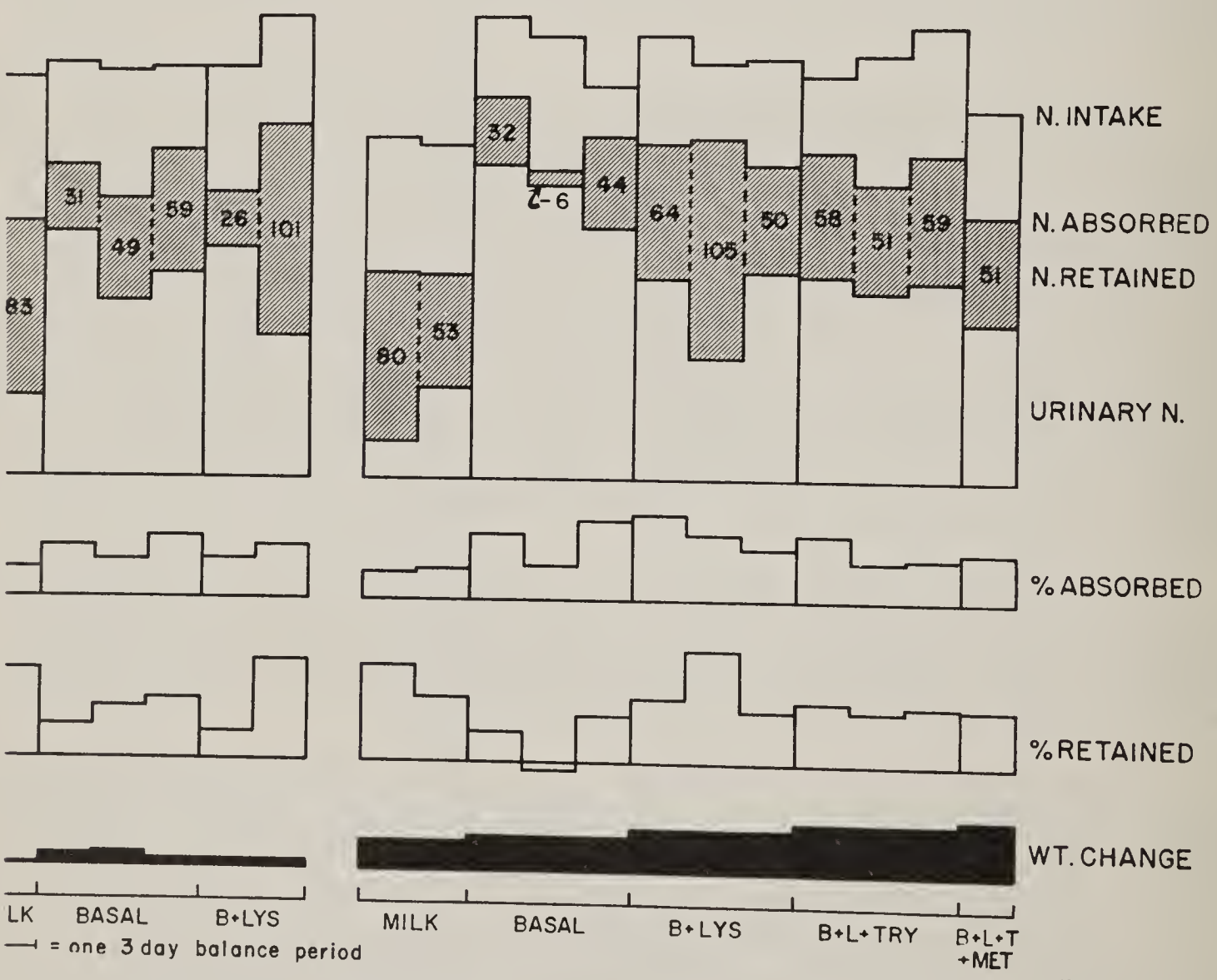


Figure 1. Amino acid supplementation of wheat protein.

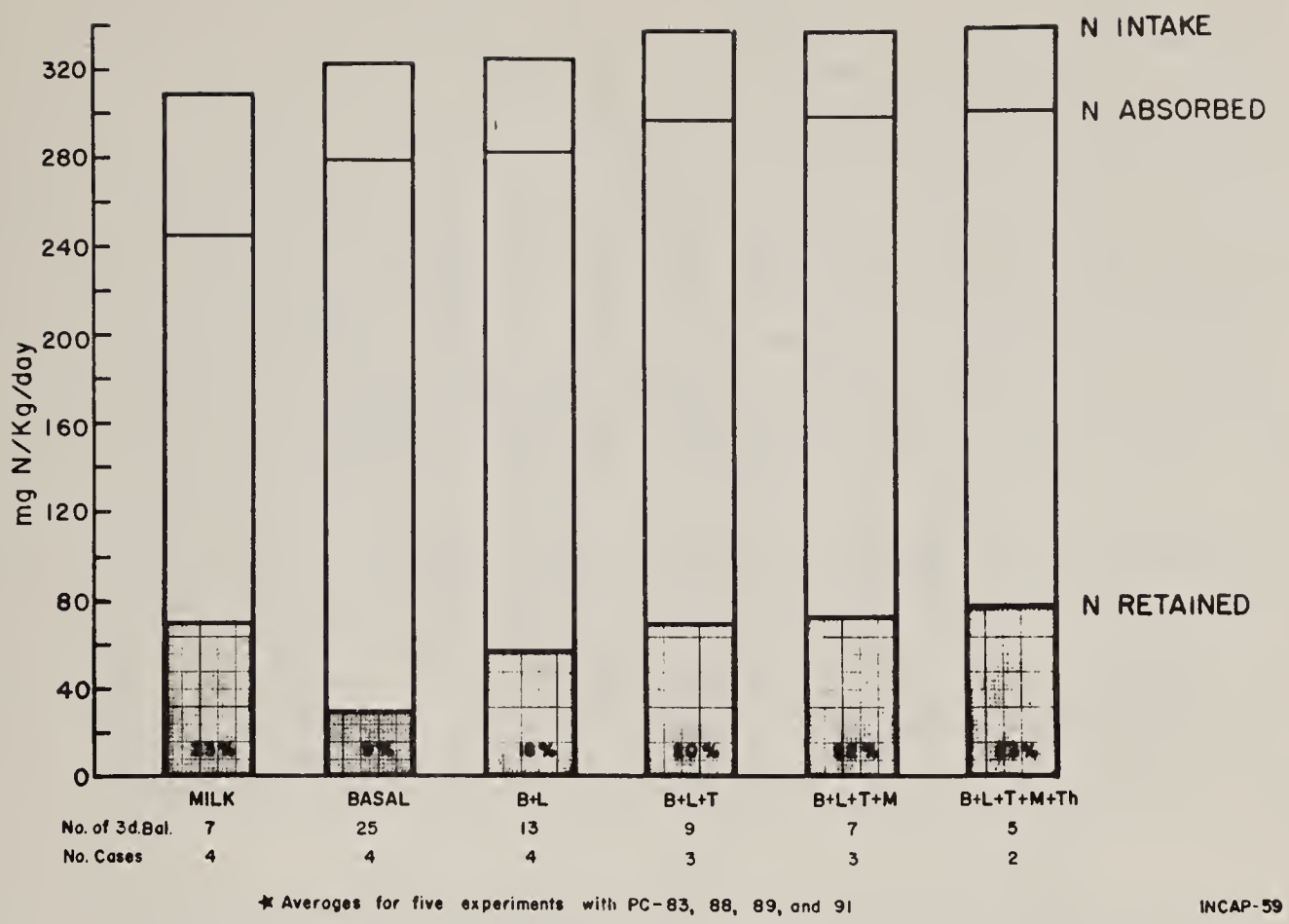


Figure 2. Effect of amino acid supplementation on nitrogen balance with diets based on wheat flour (2 g. protein, 90 cal./kg./day; averages of 5 experiments with PC-83, 88, 89, 91).

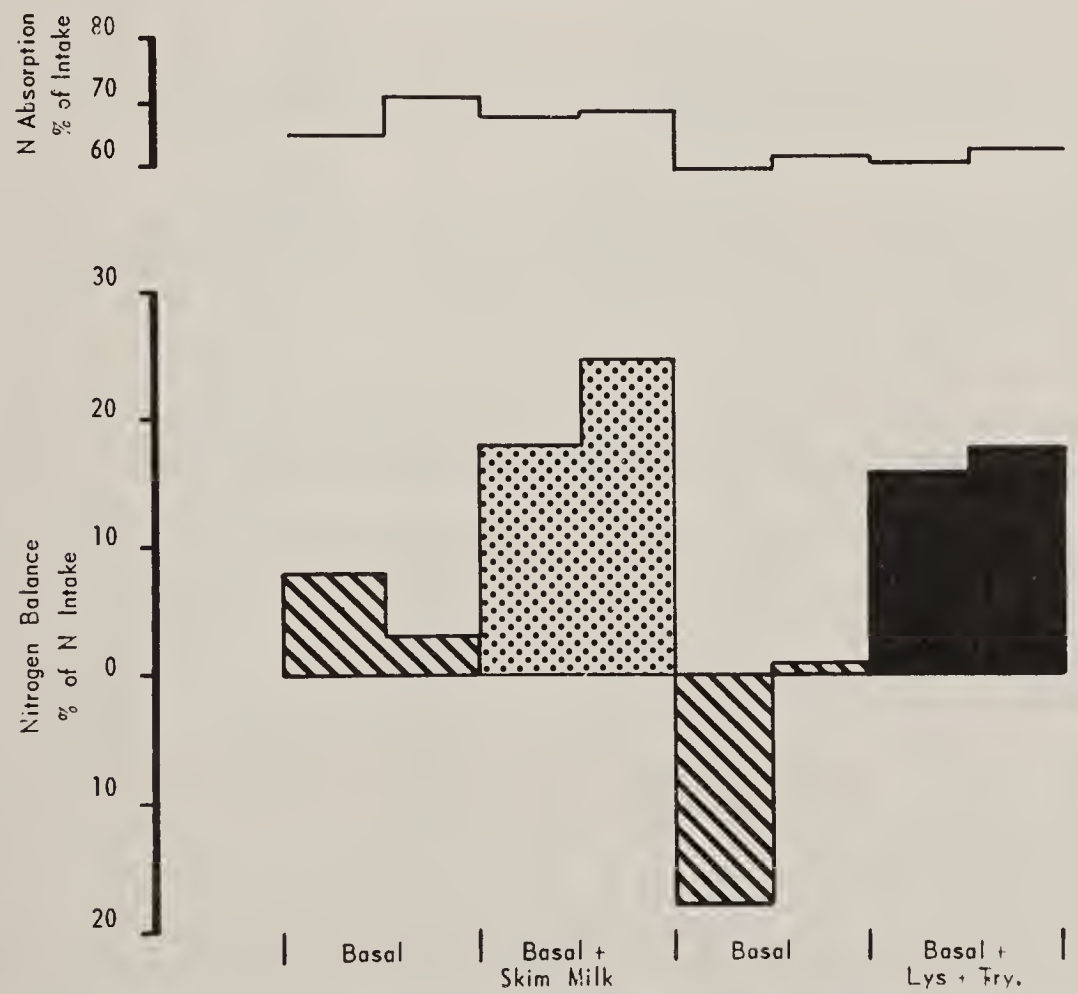


Figure 3. Nitrogen balance in young dogs fed lime-treated corn enriched with skim milk or amino acids.

The use of wheat products. Besides the common uses of wheat flour in the manufacture of bread, noodles, spaghetti, and similar foodstuffs, wheat and wheat products could also be employed very efficiently as ingredients of vegetable protein mixtures to be used as supplementary foods for infants, young children, and adults. Work along these lines has been carried out at INCAP. Several vegetable protein mixtures have been developed, one of which, INCAP Mixture No. 9, has been tested extensively and is presently being produced commercially under the name of "Incaparina" (9). The experimental formula of Mixture 9 is: ground corn 28, ground sorghum 28, cottonseed flour 38, torula yeast 3 percent, and dehydrated leaf meal 3 percent. During the development of Vegetable Mixture 9, whole ground wheat in one case and wheat flour in another were substituted for the cereal grains in this formula. Results of biological tests with chicks (8) (Table 14) show that growth was satisfactory. Barley and rice, however, induced the best growth; then came corn, oats, whole wheat, and wheat flour. The feed efficiency, however, did not coincide with the growth response, for the diet with rice showed the highest value, followed by corn, barley, wheat flour oats, and whole wheat. In general, however, all variations of the basic Vegetable Mixture 9 formula were of a good nutritive value. Similar tests carried out in young rats (11) are given in Table 15. Whole wheat produced as good growth, feed and protein efficiencies, in these tests, as were found when the mixture contained corn or other cereal grains. Wheat flour, however, gave a lower protein efficiency, although the gain in weight of the rats was as high as that found for the other cereal grains. These results can be interpreted on the basis of the total lysine content of the diets, a reflection of the lysine in whole wheat (0.215 percent) and in wheat flour (0.156 percent).

Table 14. Effect of the replacement of corn-sorghum in Vegetable Mixture 9 by other cereal grains on the growth and feed efficiency of chicks[1/]

Variation in formula of Vegetable Mixture 9	Protein content of diet	Average final weight[2/]	Feed efficiency
Wheat flour	25.3	357	2.32
Ground yellow corn	24.5	399	2.17
Ground barley	25.9	420	2.27
Ground white rice	24.7	426	2.07
Ground oats	24.7	383	2.30
Ground whole wheat	25.8	380	2.41

1/ Bressani, R. et al. J. Nutrition, 74:209-216, 1961. 2/ Average initial weight, 45 g.

Table 15. Effect of the replacement of corn-sorghum in Vegetable Mixture 9 by other cereal grains on the growth and PER of rats[1/]

Variation in Vegetable Mixture 9	Protein in diet, %	Weight gain[2/] g.	Feed efficiency	PER[3/]
Whole ground corn	13.81	128	3.5	2.05
Whole ground wheat	14.74	143	3.4	1.97
Rolled oats	15.58	151	3.3	1.93
White rice	13.97	134	3.6	2.01
Wheat flour	15.05	135	3.6	1.85
Lime-treated corn and oats	15.07	133	3.4	1.95
Lime-treated corn and rice	13.99	136	3.6	1.98
Skim milk	16.28	158	3.0	2.07

1/ Bressani, R. et al., Food Science, 1962 (in press). 2/ Average initial weight, 49 g. 3/ Protein efficiency ratio.

By-products of the wheat milling industry, such as wheat germ, have also been tested. Table 16 gives the results of an experiment in which defatted wheat germ replaced part of the corn and the sorghum in the Vegetable Mixture 9 formula. The amount of wheat germ used provided around 0.20 percent lysine and 0.10 percent threonine, amino acids found to be limiting to a small degree in Vegetable Mixture 9. The weight gain, feed, and protein-efficiency ratio of the animals fed the wheat-germ variation of Vegetable Mixture 9 were significantly higher than those obtained with Vegetable Mixture 9, and they were equal to those obtained from other variations using cowpea, soybean, and peanut flour. Table 17 shows the results of another trial in which autoclaved wheat germ replaced quantitatively the sorghum in Vegetable Mixture 9. Better growth and feed efficiency were obtained as the amount of autoclaved wheat germ was increased. From the latter two studies, it can be concluded that the substitution of wheat germ for the corn or sorghum in the mixture improved both the quality and quantity of protein in Vegetable Mixture 9.

Table 16. Effect of replacing part of the corn-sorghum combination by several concentrates on the nutritive value of Vegetable Mixture 9

Variation[1/]	Average weight[2/] gain, g.	Feed efficiency	PER
None	79	4.9	1.72
+ Lysine + threonine	116	3.6	2.29
+ Cowpea flour	100	4.2	1.98
+ Black bean flour	91	4.3	2.01
+ Soybean flour	101	4.0	2.05
+ Peanut flour	90	4.3	1.91
+ Defatted wheat germ	103	4.0	2.06

1/ Protein content of diets, 11.5%. 2/ Average initial weight, 49 g.

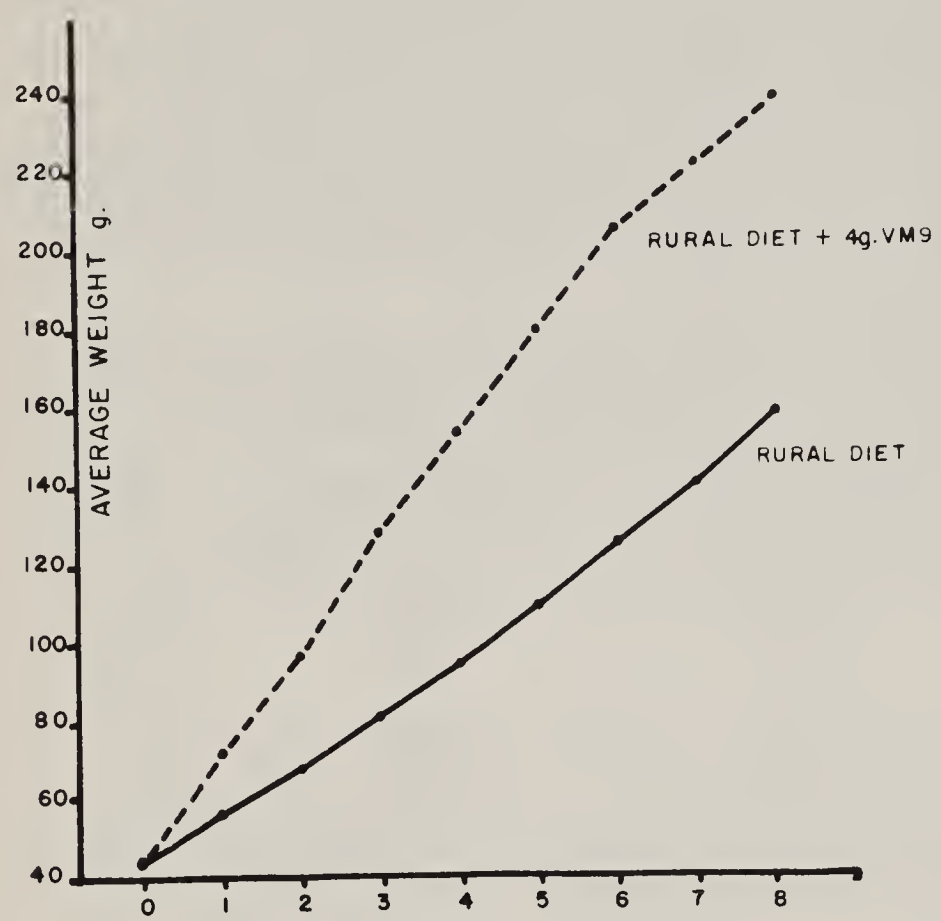
Table 17. Effect of replacing sorghum flour by autoclaved wheat germ on the nutritive value of Vegetable Mixture 9

Wheat germ % of diet	Protein in diet %	Average weight gain[1/] g.	PER	Feed efficiency
0	11.5	114	2.26	3.8
7	12.2	112	2.29	3.6
14	12.7	128	2.32	3.4
21	15.0	120	2.03	3.3
28	16.1	125	1.90	3.3

1/ Average initial weight, 53 g.

Figure 4 describes the average amounts of food consumed by children in a rural town in Guatemala (28). These figures show the dramatically low animal protein intake of some children who, consequently, are in a precarious condition. The cereal eaten by these children is, in many cases, the only food they consume, and therefore their intake of some essential amino acids is extremely limited. Their average diet contains 30 grams of bread and on a dry weight basis, the diet contains 11.4 percent protein and 0.42 percent lysine. Figure 4 also shows the average growth curves of rats fed the average rural diet for eight weeks and those of rats fed the same diet plus 4 grams of Vegetable Mixture 9, equivalent to around 1 gram of protein. Further experimental results with rats indicated that lysine was the most limiting amino acid. If wheat products were to be substituted for the corn in the diet, no improvement, either in quality or quantity, would result because wheat is deficient in lysine and

because it contains a low amount of protein. It is evident, therefore, that if an improvement is to be made in the diet, both the quality and quantity of its protein must be improved. This is what has been done by INCAP in developing vegetable protein mixtures which provide the essential amino acids in the proportions required by the organism.



AVE. FOOD CONSUMED/CHILD/DAY

FOOD	AMOUNT g.
MILK	47
EGGS	5
MEAT	7
BEANS	34
VEGETABLES	47
FRUITS	27
POTATO	3
SUGAR	18
COFFEE	5
TORTILLA	135
BREAD	30

% PROTEIN (d.w.b) 11.4

INCAP·62·64

Figure 4. Growth of rats fed a Guatemalan rural diet alone and with 4 grams of VM9 as daily protein supplement.

The peoples of the world are hungry; they need and want better foods. With the scientific knowledge already available and with improved agricultural and technological methods and greater direct assistance, foods such as wheat can become a part of the regular diets of populations now being deprived of them. It must be clearly understood, however, that these products must be used as the media through which the missing nutrients--amino acids and vitamins--can be made available to the people.

Summary. Clinical, biochemical and dietary surveys of the nutritional status of the increasingly populous countries of Central and South America, as well as studies of the chemical composition of the diets of these people, have shown that there are serious deficiencies in vitamins, minerals, and amino acids in the foods commonly consumed throughout the area. Resultant retardation in growth and bone maturation, and the more serious diseases of protein malnutrition, kwashiorkor and marasmus, and their attendant diarrheas dramatize the urgent need for improving the foods of Latin American populations. Endemic goiter, as well as other less widespread but dangerous conditions, aggravate the problem.

Food supplies that are within the economic reach of large sectors of the population are rarely large enough to provide ample nourishment, and their quality is equally inadequate. Wheat, for instance, in the form of bread and other products is greatly savored by all populations, but often its cost is prohibitive for low income groups. In those cases where better quality foods are in somewhat more

plentiful supply, problems of preservation and distribution, in addition to economic limitations, reduce the amounts actually available.

The most basic way in which to provide more and better foods for the inhabitants of Latin America is to increase agricultural production in all of these countries. The difficulties in accomplishing this objective are enormous, however, and require long-range programs of development that can be put into operation only over relatively extended periods of time, taking into consideration the conditions of the land, the assistance needed by the farmers, and the political realities that must be included in all calculations.

Some quicker and more immediate way of feeding hungry people must be devised to fill the interim during which the time-consuming and more fundamental changes are taking place. INCAP has devoted much concentrated labor to finding this quicker way. After years of experimentation with animals and humans, the Institute has produced a protein vegetable mixture known as INCAP Vegetable Mixture 9, which is suitable for supplementing the diets of the people living in underdeveloped areas of the world.

During the process of developing this mixture, many different cereals, among them wheat, have been tested to determine their nutritive value. The tests with wheat, when fed to children, showed once more that wheat flour protein is deficient in lysine. When wheat flour is properly supplemented with the limiting amino acids, however, its nutritive value, as measured by nitrogen balance techniques, is similar to that of milk when fed at isoproteic levels. As an ingredient in the vegetable mixture formula, therefore, wheat has proved effective.

Vegetable Mixture 9, now known under the generic name of "Incaparina," has met the tests to which it has been subjected and is now being produced and marketed in several Latin American countries.

Acknowledgment. The author is indebted to Miss Marina Flores for a large amount of information presented in this report, and to Mrs. Frieda Whitman for her help in the preparation of this manuscript.

REFERENCES

1. Adams, R. N. Food Habits in Latin America: A Preliminary Historical Survey. In: Human Nutrition Historic and Scientific, edited by Iago Galston. New York, International Universities Press, Inc., 1960, p. 1-22. Institute of Social and Historical Medicine Monograph III.

2. Aguilar, T., and Cáceres Bedoya, R. Estudio de la nutrición en niños pobres de Lima. I. An. Fac. Med. Lima 37:203-233, 1954.

3. América en Cifras, 1960. 1. Estadísticas demográficas. Unión Panamericana, Departamento de Estadística, Secretaría General de la Organización de los Estados Americanos, Washington, D. C.

4. Béhar, M. Characteristics and epidemiology of protein malnutrition in children. Tenth Pacific Science Congress, Honolulu, Hawaii, Aug. 21-Sept. 6, 1961.

5. Bengoa, J. M., and Liendo Coll, P. Consumo de alimentos en Venezuela durante el anõ, 1949. Arch. Venezol. Nutrición, 1:315-345, 1950.

6. Bengoa, J. B., Obregón, V. M., and González, M. Influencia del factor económico en el consumo de alimentos en el medio rural. Arch. Venezol. Nutrición 3:343, 1952.

7. Bengoa, J. M., and Saldivia, F. Encuesta alimentaria en 36 familias de Puerto La Cruz. Arch. Venezol. Nutrición 2:327, 357, 1951.

8. Bressani, R., Aguirre, A., Elías, L. G., Arroyave, R., Jarquin, R., and Scrimshaw, N. S. All-vegetable protein mixtures for human feeding. IV. Biological testing of INCAP Vegetable Mixture 9 in chicks. J. Nutrition 74:209-216, 1961.

9. Bressani, R., Elías, L. G., Aguirre, A., and Scrimshaw, N. S. All-vegetable protein mixtures for human feeding. III. Development of INCAP Vegetable Mixture Nine. J. Nutrition 74:201-208, 1961.

10. Bressani, R., Elías, L. G., Scrimshaw, N. S., and Guzmán, M. A. Nutritive value of Central American corn. VI. Varietal and environmental influence on the nitrogen, essential amino acid and fat content of ten varieties. Cereal Chem. 39: 59-67, 1962.

11. Bressani, R., Elías, L. G., and Scrimshaw, N. S. All-vegetable protein mixtures for human feeding. VIII. Biological testing of INCAP Vegetable Mixture Nine in rats. J. Food Science, 1962 (in press).

12. Bressani, R., Jarquín, R., and Elias, L. G. Composición química y digestibilidad del Quinamul (Ipomonea sagittata, Lab.) y del Pangola (Digitaria decumbens, Stent.) en Guatemala. Turrialba 8:110-116, 1958.

13. Bressani, R., Jarquín, R., and Elias, L. G. Composición química y digestibilidad de siete plantas forrajeras en Guatemala. Turrialba 8:117-122, 1958.

14. Bressani, R., and Marenco, E. The enrichment of lime-treated corn flour with proteins, lysine and tryptophan and vitamins (in preparation).

15. Bressani, R., Paz y Paz, R., and Scrimshaw, N. S. Corn nutrient losses. Chemical changes in corn during preparation of tortillas. J. Agr. Food Chem. 6:770-774, 1958.

16. Bressani, R., and Rios, B. The chemical and essential amino acid composition of twenty-five selections of grain. Cereal Chem. 39:50-58, 1962.

17. Bressani, R., Valiente, A. T., and Tejada, C. All-vegetable protein mixtures for human feeding. VI. The value of combinations of lime-treated corn with cooked black beans. J. Food Science (in press).

18. Bressani, R., and Villarreal, E. M. de. Nitrogen balance of dogs fed lime-treated corn supplemented with proteins and amino acids. (in preparation).

19. Bressani, R., Wilson, D. L., Behar, M., and Scrimshaw, N. S. Supplementation of cereal proteins with amino acids. III. Effect of amino acid supplementation of wheat flour as measured by nitrogen retention of young children. J. Nutrition 70:176-186, 1960.

20. Castro, J. de. La alimentación en los trópicos. México, Fondo de Cultura Económica, 1946, p. 127-196.

21. Castro, J. de. Geography of hunger. Hunger in Brazil, 2nd ed. Río de Janeiro, Empresa Gráfica "O Cruzeiro" S. A., p. 404, 1948.

22. Castro, J. de, Souza Luz, H. de and Borges, P. Pesquisa sobre o estado nutritivo de escolares do distrito federal. Universidade do Brazil, Instituto de Nutricao, Trabalhos e Pesquisas II:71-82, 1949.

23. Collazos, C. C., White, H. S., Reh, E., Huenemann, R. L., and White, D. L. Dietary surveys in Peru. I. San Nicolas, a cotton hacienda on the Pacific Coast. J. Am. Dietet. Assoc. 29:883-889, 1953.

24. Conferencia de Nutrición. Montevideo, Julio de 1948. Montevideo, Comisión de Alimentación, Filial de la FAO, 1950.

25. Conference on Nutrition Problems in Latin America 3rd. Caracas, Venezuela, 19-28 Oct. 1953. Report, Rome, FAO 1954.

26. Escudero, P. El presente y el futuro del problema alimentario de Bolivia. Buenos Aires, Instituto Nacional de la Nutrición, Publicaciones Científicas, CNP30, 1947, 214 p.

27. Escudero, P., and Rothman, B. Caracteres de la alimentación de los internados escolares de la Argentina. I. Valor calórico del régimen de alimentación ofrecido. Rev. Asoc. Argentina Dietol. 1:225-233, 1943.

28. Flores, M. Personal communication.

29. Flores, M. Food patterns in Central America and Panama. In: Tradition Science and Practice in Dietetics. Proceedings of the 3rd International Congress of Dietetics. London 10-14 July, 1961. Yorkshire, Great Britain, Wm. Byles and Sons, Ltd. of Bradford, 1961, p. 23-27.

30. Flores, M. y García, B. The nutritional status of children of pre-school age in the Guatemalan community of Amatitlan. 1. Comparison of family and child diets. Brit. J. Nutrition 14:207-215, 1960.

31. Flores, M., Flores, Z., and Meneses, B. Estudios de hábitos dietéticos en poblaciones de Guatemala. IX. Santa Catarina Barahona. Arch. Venezol. Nutrición 8:57-82, 1957.

32. Flores, M., and Reh, E. Estudios de hábitos dietéticos en poblaciones de Guatemala. IV. Santa María Cauqué. Suplemento No. 2 del Boletín de la Oficina Sanitaria Panamericana, Publicaciones Científicas del INCAP, p. 163-173, 1955.

33. Food and Agriculture Organization of the United Nations. Food Balance Sheets. Rome, FAO, 1953.

34. Food and Agriculture Organization of the United Nations. Report of the FAO Committee. Rome, Italy, 24-31, October 1955. FAO Nutritional Studies No. 16. Rome, 1957.

35. Food and Agriculture Organization of the United Nations. The State of Food and Agriculture, 1960.

36. Fourth Conference on Nutrition Problems in Latin America. Guatemala City, 1957.

37. Gandra, Y. R. Inquérito sobre o estado de nutricao de un grupo de populacao da cidade de Sao Paulo. III. Investigacao sobre a ocorrencia de hipo hipovitaminoses do complexo B (tiamina, riboflavina e niacina). Arq. Fac. Hig. Sao Paulo 9:29-112, 1955.

38. Gómez, F. Hambre cronica. Bol. Med. Hosp. Infantil México 7:479-484, 1950

39. Gonzales Puccini, A., Bengoa, J. M., Liendo Coll, P., and Sanchez Carrillo, A. Hojas de balance de alimentos, año 1950. Arch. Venezol. Nutrición 2:369-376, 1951.

40. Hueneman, R. L., Bruch T. H. A., and Scholes, R. T. A dietary survey in the Santa Cruz area of Bolivia. Am. J. Trop. Med. Hyg. 6:21-31, 1957.

41. Informe sobre condiciones alimentarias en el municipio de Palestina (Caldas) Colombia. Programa de Encuestas Alimentarias (Servicio Asistencia Social, Food and Agriculture Organization of the United Nations, Instituto de Nutrición). Mimeo report, 1958.

42. La realidad alimentaria ecuatoriana. Un estudio de cinco encuestas alimentarias. Quito, Ministerio de Previsión Social y Sanidad. Instituto Nacional de la Nutricion, 1956, p. 5-105.

43. Lowenstein, F. Panorama alimentar no Brasil. Arq. Brasil. Nutricao 15: 25-41, 1959.

44. Luna de la Fuente, R. Ensayo de panificación con mezclas de harinas de trigo y de tres variedades de camote. Lima (Perú) Estación Experimental Agrícola de la Molina. Informe Mensual 34 (393) p. 1-5, 1960.

45. Paez Pumar, E., Liendo Coll, P., Planchart, A., and Rivas Larralde, E. Algunos aspectos nutricionales de un grupo de escolares de Caracas. Arch. Venezol. Nutricion 2:97-123, 1951.

46. Rosenberg, H. R., and Rohdenburg, E. L. The fortification of bread with lysine. 2. The nutritional value of fortified bread. Arch. Biochem. Biophys. 37: 461, 1952.

47. Scrimshaw, N. S., and Béhar, M. Protein malnutrition in young children. Science 133:2039-2047, 1961.

48. Scrimshaw, N. S., Guzmán, M. A., and Ascoli, W. Nutrition research in Latin American countries. Presented at the Tenth Pacific Science Congress on Nutrition, Honolulu, Hawaii, August 21-September 6, 1961.

49. Segovia, N. Valor nutritivo de la dieta media estadística nacional y las posibilidades de su mejoría por suplementación. Rev. Chilena Hig. 14:259-271, 1952.

50. Squibb, R. L., and Scrimshaw, N. S. Relación de los forrajes con los problemas de la nutrición en los trópicos americanos. Suplemento No. 1 del Boletín de la Oficina Sanitaria Panamericana, Publicaciones Científicas del INCAP, p. 110-118, 1953.

51. Summary of Four-Year Reports on Health Conditions in the Americas. Pan American Sanitary Bureau, Regional Office of the World Health Organization, Scientific Publication No. 40. Washington, D. C., 1958.

52. Thonnard-Neumann, E. Klinische Beobachtungen zu Klima und Ernährung in Kolumbien (Clinical observations on climate and nutrition in Colombia). Ztschr. Tropenmed. Parasitol. 8:367-376, 1957.

53. Trulson, M. F., Collazos, C. C., and Hegsted, D. M. Growth and development of Peruvian children. I. Carquin and San Nicolas. Pediatrics 17:510-523, 1956.

54. Trulson, M. F., Collazos, C. C., and Hegsted, D. M. Growth and development of Peruvian children. II. Children from two areas--jungle and coastal. J. Am. Dietet. Assoc. 33:1019-1026, 1957.

55. Waterlow, J., and Vergara, A. Protein malnutrition in Brasil (FAO Nutritional Studies No. 14). Rome, Food and Agriculture Organization of the United Nations, 1956, p. 40.

Discussion. Questions were concerned with the value and supply of quinoa, a South American food seed, statistics on kwashiorkor with regard to effect of low protein diets on mortality and marginal effects, critical amino acid shortages in South America and the lysine of legumes.

Quinoa is used as a cereal in Chile and Peru and has a high-quality protein, higher in lysine than wheat. However, its production is very limited, being presently confined to the highlands of Peru.

Areas with evident kwashiorkor from low protein diets showed definitely higher mortality rates. Marginal effects of low protein diets have been the subject of a publication.

Probably lysine is the most critical of the amino acid deficiencies of the South American diet. The availability of lysine in digestion is as much of a problem as the total supply.

Legumes are a good source of lysine. However, a principal source, beans, is cooked for a long time in normal use, and there is some loss of availability of lysine. Legume and corn proteins supplement each other very well, the best ratio being about one to one.

FOOD SUPPLY AND REQUIREMENTS IN TROPICAL AFRICA

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Food balance sheets compiled by the United States Department of Agriculture for 21 countries of Africa serve roughly to characterize the dietary patterns of the inhabitants of that continent (1). Heavy reliance on cereals, starchy roots, and starchy fruits is brought out by average starchy-staple ratios of 0.66 for northern Africa (including Ethiopia and Sudan), and of 0.72 for Africa south of the Sahara. Low consumption of animal products, another feature of most African diets, is illustrated by the small part of the total calorie supply derived from meat, fish, cheese, milk, and eggs; it amounts to 10.6 percent of total calories in northern Africa and 4.7 percent of the sub-Saharan countries. And the balance sheets show the starchy staples of the Mediterranean world to be almost entirely different from those of sub-Saharan Africa. In Algeria, Egypt, Libya, Morocco, and Tunisia, wheat contributed from 500 to 1,000 calories per person per day, and barley from 300 to 700 calories, except in Egypt where its place is taken by corn. South Africa, too, consumes large quantities of wheat (estimated at 465 calories per person per day), but no barley. In the other African countries, consumption of wheat (mostly imported) is estimated at 10 to 130 calories per day, and barley is used only in Ethiopia. This much can be learned from the balance sheets, but they are too general to reveal the most basic division in African diets, that between root eaters and cereal eaters,and the production and population estimates on which they are based are too unreliable to permit any inferences about the levels of nutrient intake or the adequacy of nutrition (cf. 2, 3).

The distinguishing feature of diets of the African population living in and above the equatorial rain forest is their heavy reliance on root crops such as yam, manioc, taro, and malanga, and on bananas and plantains. Maize is also grown in this area but is rarely the dominant staple. Along the west coast, from the Bandama River to the Senegal, rice is the preeminent staple in most diets. North, east, and south of this region of high rainfall the dominant staples are sorghums, millets, and corn, with corn particularly important in the east and south. The distinction between diets based on cereals and those based on roots and plantains is particularly important for protein nutrition because of the relatively small amount and poor quality of proteins in the roots and starchy fruits. This distinction is erased by "national" food budgets as given in the Department's balance sheets for most of the sub-Saharan countries. The French West African balance sheet shows 1,430 calories per person per day from cereals and 750 calories from starchy roots, but in fact large populations rely almost entirely on cereals, others almost entirely on manioc and yams. French Equatorial Africa extend from 22°N latitude to 5°S, and includes a wide variety of climates and agricultural systems, from the cattle-herding areas on the edge of the Sahara, through grasslands, forests and swamps farther south, to the savanna of the southern Congo (Brazzaville). It contains diets based on animal products, others based on cereals, on roots, or on plantains. But the kind of diet suggested by the balance sheets--40 percent cereals, 30 percent roots, 6 percent bananas and plantains, and 4 percent animal products--was found to be eaten by no one. What has been said of the two great French federations is also true of Congo (Leopoldville), Nigeria, Ghana, and in fact of every southern African country with the possible exception of Tanganyika and Kenya.

Africa is still predominantly rural, and most rural Africans still eat the food that they and their neighbors grow. In traditional African society about the only purchased foodstuff is salt, and reliance on home-produced foods still characterizes the population over large areas. Where cash-cropping and specialization in

production have become general, as in the cocoa-producing areas of western Nigeria, purchase of foodstuffs has become common, but such areas are still the exception. Movement of staple foodstuffs over long distances is also uncommon, although some of the larger cities may draw their corn or manioc from farms several hundred miles away. Reasons for the relatively high self-sufficiency of African consumers, for the compartmentalization of the food economy, lie in the high cost of transport and marketing, and the persisting unfamiliarity of many Africans with the market economy, including a tendency to regard as inappropriate the exchange of certain commodities for money. But the degree of African consumers' understanding of the manifold uses of money, and of their reliance on the exchange economy, runs the gamut from that of the city merchant who buys everything that he consumes to the herding nomad who buys almost nothing. Because economic exchange is still so little perfected in tropical Africa, the economies of the African countries are not national economies at all. Rather, they are collections of small, relatively self-contained village and district economies that are loosely tied together by limited commerce in farm produce and consumer goods, by taxes and public works, and by labor migration.

Under these circumstances, national food balance sheets have extremely limited uses, even when they are prepared from fairly reliable statistics of population, production, and trade. The balance sheets of the U. S. Department of Agriculture were not. The production data on which they are based come mostly from rough estimates made by agricultural officers, when they are not obtained by working the food balance sheet in reverse, that is, by estimating what production, and in what proportions, would be required to provide an assumed consumption of calories per capita (cf. 4). If the production data are bad, population figures may be only a little better. Populations reported for some of the African countries, notoriously Liberia and Ethiopia, are only quantified guesses. Other estimates based on some sort of registration system or census may also be disappointingly unreliable. It was disturbing to find the censuses of the early 1950's returning counts markedly in disagreement with the standing estimates--7 and 9 percent smaller for Mozambique and Angola, 20 and 25 percent greater for Nigeria and British East Africa--but the 1960 census in Ghana, which showed a population 37 percent larger than the standing estimate based on the 1948 census, suggested that African population figures have not yet achieved a reasonable degree of reliability.

Under these circumstances, when variation within a country is great and national statistics are badly defective, the only way to find out how much food people eat is by direct observation and measurement, the method of the best dietary survey. If we also want to know whether they eat enough, we must combine the dietary survey with clinical and examination by physicians familiar with nutritional diseases and with laboratory tests made by biochemists. Medical examination alone is probably not enough because some symptoms of nutritional deficiency can result from a variety of other causes, including some widely prevalent tropical diseases. These studies are costly, and the number which have been made is pitifully few, too few, because of the great local variability of African diets, to permit us to say much in general terms about the adequacy of diets, or to identify areas of serious deficiency. The results of thirteen such studies are presented here--seven in Nigeria, three in Upper Volta in former French West Africa, and three in Congo (Brazzaville) in former French Equatorial Africa.

The Upper Volta studies were conducted in 1953 and 1955. Those in Kokoroue and Sinorosso consisted of the weighing of all food ingested during three 4-day periods, one in the rainy season, two in the dry season. The Issigui study covered only one 4-day or 7-day period at the end of the dry season. In Kokoroue, 36 families (368 individuals) were studied; in Sinorosso, 33 families (254 individuals); and in Issigui, 40 families (210 individuals). (They are reported in 5, 6, and 7.) The Congo studies were conducted in 1956 and 1957 over a 4-week period, one set of families being studied each week. In Madingo-Kayes, 32 families (252 individuals)

were studied; in Mindouli, 58 families (335 individuals); and in Mossendjo, 96 families (514 individuals). (They are reported in 8, 9, and 10.) The Nigerian studies were made between 1954 and 1957 and covered three 10-day periods (the first two days and the last day were dropped), one just after harvest, one midway to next planting, and one two weeks before harvest. The number of individuals in the seven samples ranged from 33 to 108, and averaged 81. (They are reported in 11 and 12.) These studies suggest the kinds of nutritional conditions that are found, and something of the difficulties encountered in interpreting dietary and medical findings. Calorie, protein, fat, and calcium content of diets in the thirteen communities are shown in Table 1.

Table 1. Nutrient composition of some average daily diets in central and west Africa (all figures per person per day)[1/]

Area	Calories		Protein (grams)		Fat (grams)	Calcium (mg.)
	Observed	% of standard	Observed	% of standard	Observed	standard
Cereals						
Upper Volta						
Issigui	2,446	99	80	87[2/]	35	421
Kokoroue	2,147	85	66	64[2/]	24	384
Sinorosso	2,974	120	92	104[2/]	41	332
Nigeria						
Jarawaji	2,631	125	96	250[3/]	33	1,225
Tangaza	1,664	77	52	130[3/]	22	260
Bunga	2,263	106	75	190[3/]	31	720
Tungan Maidubu	2,467	108	103	240[3/]	27	475
Langai	2,057	92	77	200[3/]	39	530
Roots						
Congo (Brazzaville)						
Madingo-Kayes	1,878	94	45	88[4/]	15	392
Mindouli	1,765	92	40	80[4/]	45	480
Mossendjo	2,560	114	48	95[4/]	40	496
Nigeria						
Bero Okuta	1,852	86	47	80[3/]	13	400
Mbanege	1,923	91	51	80[3/]	26	500

1/ Sources: For Nigeria, B. M. Nicol, "The Calorie Requirements of Nigerian Peasant Farmers," and "The Protein Requirements of Nigerian Peasant Farmers," Brit. J. Nutr., Vol. 13, 1959, pp. 293-320; for Upper Volta, from A.O.F., Org. de Rech. sur l'Aliment. et la Nutr. en Afrique, Etudes Monographiques de Village, 1953 and 1955 (mimeo); for Moyen Congo, from A.E.F., Dir. Fed. du Serv. Gen. Mobile d'Hygiene et Prophylaxie, Sec. Aliment. et Nutr., Enquête nutritionelle dans le district de Mossendjo(mimeo, 1956), ibid., Mindouli (1957), and ibid., Madingo-Kayes (1957). 2/ Protein requirements computed on basis of 100 grams for an adult male. 3/ Protein requirements are Safe Practical Allowance, computed in terms of reference protein. Safe Practical Allowance is 50 percent greater than Minimum Requirement. 4/ Protein requirements computed on basis of 1 gram protein per kilogram of body weight of an adult male.

The staple foods in the cereal areas of Upper Volta and Nigeria were sorghums and millets, probably mostly the latter, and including fonio or acha (Digitaria exilis) and finger millet (Eleusine coracana). These cereals are reported to have supplied from 67 to 82 percent of all calories in six of the communities in this area; in Langai, which is on the central Nigerian plateau where root crops are also of some importance, the millets and sorghums supply 57 percent of food calories; and in the one-week investigation in Issigui, the investigators found them supplying 97

percent of all calories. Protein, too, came largely (47-68 percent) from the cereals, but was supplemented in several of the Nigerian communities by small amounts of meat, milk, and fish. Millet and sorghum were also the principal source of fat.

The Nigerian populations living in the root zone relied primarily on yams, including taro and malanga, for food calories (62 percent in both communities) and for protein (63 and 65 percent). These are not high-quality proteins; the protein score of the diets is 50, compared with 75 to 80 for the Nigerian cereal diets (the limiting amino acids are methionine and cystine). In the three Congo communities, although the staple root, here manioc, supplied from 50 to 60 percent of food calories, its protein contribution was insignificant. (Manioc has little protein and that of poor quality.) In Madingo-Kayes, which lies north of Point Noire, fish furnished most protein to families living on the seashore or near lakes, and game to families living in the forest. Villagers in Mindouli in the Niari Valley obtained most of their protein from peanuts (45 percent), and, when they had the money, from dried fish (25 percent), imported from Angola and Mauritania. In Mossendjo, northwest of Brazzaville, the protein sources were peanuts (27 percent) and fish and game (29 percent). In the Congo villages, fat came from palm oil and peanuts.

Examination of detailed lists of foodstuffs consumed by the populations included in these 13 studies and of the differences among them confirms our notion that rural Africans rely almost entirely on commodities produced nearby. A notable exception is the district of Mindouli in the Niari Valley, where there has been some development of cash-cropping and imported fish has become an important source of protein. Other diet lists show only small quantities of salt, of cube sugar, and of rice. The Congo studies demonstrate how much the diet can vary in short distances with change in climate, terrain, and consumer preference.

These diets appear monotonous in terms of the staple foods, but consumers find variety in the ways in which the starchy staple is prepared, and in the ingredients of the sauce which is eaten with it. Over the course of a year, the sauces may contain a considerable variety of vegetables, green leaves, oilseeds, nuts, fruits, and fungi, most of them unfamiliar to inhabitants of the temperate zone and many with no name in any European language. Sinorosso menus for one week, for example, contained five different kinds of leaves, seed pods, melon seeds, residues from millet beer, shea butter and fruit, African eggplant, tomatoes, fermented locust beans, ashes from millet stalks (for salt, one supposes), and caterpillars.

How good are these diets? Attempts to compare their supply of calories, protein, and other nutrients with established standards raise the question of the appropriateness of the standards themselves. Calorie standards used in the Upper Volta studies were those of the Section of Food and Nutrition of the National Institute of Hygiene in Paris; they call for 3,000 calories for an adult male and 100 grams of protein. For the Congo studies, the 1953 standards of the Food and Nutrition Board of the National Research Council were used; calorie requirements for an adult male, adjusted for mean temperature and body weight, were computed as 2,520; protein was set at one gram per kilogram of body weight. The calorie standards used in the Nigeria studies are based on the recommendations of the Second Committee on Calorie Requirements of the Food and Agriculture Organization of the United Nations and range from 2,400 to 2,560 calories for an adult male. Protein requirements were computed by the method of protein scores as recommended by FAO, Committee on Protein Requirements (1957). Table 1 expresses Nigerian protein requirements as a percentage of the so-called "safe practical allowance" which is 50 percent greater than the minimum requirement. Dr. Nicol points out that the main factor affecting calorie requirements in the Nigerian studies was the amount of physical activity, and that this is not accounted for in the standards. The cattle herdsmen and farmers in Jarawaji and Bunga, for example, daily covered long distances herding their cattle or going to and from their farms; and the women in Jarawaji walked as far as 20 miles

to markets two or three times a week, as well as working hard on their farms. On the other hand, the women of Tangazi, who were on short rations, worked as little as possible during the hungry period (11, p. 304).

Calcium standards, not used in Table 1, were taken to be 1,000 milligrams per day in the Congo studies.

Against the standards used in these three sets of investigations, deficiencies appear 8 times in calories, 7 times in proteins, and 12 times in calcium. If we extend to the French studies Nicol's estimate that the Nigerian studies are subject to an error of ± 15 percent, the table shows one community (Tangaza) to be short in calories and 4 short in protein.

More reliable information about the adequacy of diets can be got from the clinical and biochemical examinations. These are available only for the Nigerian and Congo studies. (The reports of the Upper Volta studies include statistics of a long list of symptoms, but they do not contain the physicians' general evaluation of nutritional adequacy.)

In the Nigerian studies calorie supply was found to be generally adequate except in Tangaza where the millet crop had partially failed because of poor growing conditions. Elsewhere, crops were average or better. At Bero-Okuta farmers had tended to oversell their yam crop, game, and other foodstuffs since the opening of a motor road, eight years before, connecting with the populous cocoa-producing regions to the south. As a result, many of them found themselves short, both of food and of money at the end of the crop year.

In general, "Good agreement between dietary calories and calorie requirements was obtained for men and women over 12 years of age in those communities whose way of life was not associated with considerable physical exertion, provided food supplies were not short" (11, p. 306). No obvious correlation appeared between calorie value of diets and body weight. Children under 12 were not given enough food to satisfy their calculated energy requirements. But "Certain age groups, for example the 10-12 year old Jarawaji and Tangaza children, were so erratic in their eating habits that it was impossible to obtain satisfactory records of their food consumption" (11, pp. 295-296). Boys were becoming independent and might be away from their homes for many hours or even days hunting or fishing for food which they cooked and ate in the bush. The error in estimating the amount of food obtained elsewhere than from the compound kitchen was believed to be ± 50 percent, but on an average, it was thought that only about 20 percent of all food eaten was so obtained. It was also impossible to separate the consumption of food by pregnant and lactating women from that of other women because they frequently all ate from a common pot.

With regard to protein, Nicol found no statistically significant relationship between protein intake and body weight, but adults in the cereal areas were significantly taller, if only slightly, than adults in the yam area. Among 138 children examined in the north, 3 were found suffering from clinically detectable protein malnutrition, and the same number were found among 56 children examined in the south. The difference in proportions is not statistically significant. Protein malnutrition was detected in only one individual over nine years of age.

Nicol concludes "It is noteworthy that so little difference was found between the clinical condition of the two groups of African peasants whose diets supplied, on the one hand, a daily average of 85 g. protein, which scored 77 according to the provisional amino-acid pattern recommended by the FAO ..., and, on the other hand, 51 g. protein which scored 50. A small difference in adult height and a slightly higher incidence of protein malnutrition in young children in the yam-eating communities were the only positive findings. It seems reasonable to assume that a

daily intake by an adult of 51 g. protein of score 50 ... is as satisfactory for normal adult maintenance in such rural tropical communities as an intake of 85 g. which scores 77 .... Finally, it seems justifiable to conclude that the safe practical allowance of dietary protein suggested by FAO Committee on Protein Requirements (1957) is unnecessarily high" (12, pp. 318-319).

The Congo investigators examined a total of 10,000 people, and made tests of the blood, stool, and urine of a much smaller number. They looked especially for signs of protein malnutrition. They found none. They did find a high incidence of enlarged liver, but comparison with the occurrence of enlarged spleen caused by malaria indicated fairly conclusively that this was the cause. On some individuals they found slight discoloration of the tips of the hair, a condition probably caused by intestinal parasites. Despite the large deficit in calcium compared with the theoretical requirements, no clinical or biological signs of calcium deficiency were found. Even in the forested area of Mossendjo where there is little direct sunlight, there were no cases of rickets. Iron consumption was high, but it was felt that perhaps it was still not high enough to offset the effects of intestinal parasites and sickle-cell anemia.

The only signs suggesting a vitamin deficiency were lesions of the mouth and gums. But consumption of vitamin C was high, as much as 200 percent above the recommended allowance. Consumption of vitamin A was also much above the standard, and it was suggested that perhaps the oral lesions resulted because the excessive intake of A was displacing or neutralizing the effect of C. This hypothesis, too, had to fall when it was observed that the same symptoms were found in parts of the territory where intake of vitamin A was at about the standard and intake of vitamin C was much above it. The most likely explanation appeared to lie in the low intake of the B vitamins, especially of riboflavin, but there were no other signs of vitamin B deficiencies. The cause was not pellagra, because there were no other pellagroid symptoms and consumption of vitamin C was ample.

The investigators found no cases of beri-beri, despite the low intake of thiamine, and suggested that this may be because calorie consumption was generally low. They also warned about the danger of trouble if this balance were to be upset by changes in the diet, such as an increased consumption of polished rice.

In all three districts they found that the general physical conditions of adults was excellent. The general state of children, too, was very good, except for infants of 6 to 12 months and for children in school. (But of 4,698 children examined in Mossendjo district, only 35 were found to be in poor condition, only 2 in bad condition.) The health of infants fell off at about 6 or 7 months, probably when they first contracted malaria and intestinal parasites (especially ankylostomes). School children, however, showed definite signs of dietary deficiencies (9 percent in Madingo-Kayes) of calories and vitamins, but not of protein. This was almost certainly because they did not have time to obtain snacks by hunting and gathering in the bush.

In summarizing the clinical investigation in Mossendjo, the report states, "... the clinical enquiry has shown us the trivial importance of malnutrition in the local pathology. On the other hand, it has demonstrated the ravages caused by pulmonary infections, sickle-cell anemia, and malaria which together decimate the child population" (10, p. 21).

These studies must not be taken as representative of all tropical Africa. They suggest, however, that in the areas where they were undertaken nutritional deficiencies were not a major cause of illness or lack of vigor, and where food supplies were inadequate it was because of local deficiencies in production--one might as well say, in income--and not because of inadequate production generally. (Tangaza, for example, is within 30 miles of Sokoto, where millet could be bought throughout the period of the study, although at prices twice the normal level.)

Inadequacies in the marketing and distribution system (the imperfect development of a market economy) are principal causes of local shortages, low productivity, and of poverty. They also make extremely difficult and costly any attempt to distribute widely supplies coming from abroad. On the other hand, given better internal communications, nearby supplies can almost always be found to meet local shortages.

Increased incomes and better internal distribution of foodstuffs will make better nutrition possible, but they will not necessarily make it a fact. As the African consumer moves from a world of custom to one of rational choice, good feeding habits developed in the traditional society are apt to be forgotten. In particular, the numerous supplementary foodstuffs, obtained by hunting and gathering, which often make an important contribution to good nutrition, may no longer be available, and diets may worsen. The wide range of goods available in a market economy may also tempt consumers to spend money for non-food items at the cost of adequate nutrition. Probably the only way to combat the tendency for diets to deteriorate when consumers are familiarizing themselves with the workings of a money economy is by education and propaganda, especially in the feeding of children. Mothers of young children are particularly receptive to information about infant care. Programs to improve infant feeding by education have been successful in many places, but they are still too few and too limited.

Foods of the temperate zone are not needed in Africa to ensure an adequate level of nutrition. They are, however, gaining an increasing market among African consumers who have been brought into closer contact with the world economy by engaging in the production of crops for market, by working for wages, or by residing in urban centers.

To say that the countries of Africa can feed their people adequately with the products of their own agriculture is not to say that they will not find it desirable to import foodstuffs from other parts of the world. As African consumers have become more familiar with exotic foods, and as their incomes have risen, they have added a fairly wide range of new commodities to their diets. These new foods are purchased not because they are needed, in a nutritional sense, but because they are desired for variety, for their ease of preparation, or because of status attached to their use. In the cities of Africa wheat-flour products, canned and dried meat and fish, and canned milk are important consumer goods. Supermarkets in some African cities sell a range of foodstuffs comparable to that offered in many American cities, and probably more international in origin. If the new African governments permit continued import of foodstuffs from abroad, consumption of these exotic commodities will surely increase with rising incomes and wider experience.

CITATIONS

1. U. S. Dept. Agr., Foreign Agricultural Service, Food Balances in Foreign Countries. Part IV: Estimates for 28 Countries of Africa and Western Asia (Feb. 1961).

2. Jones, W. O. "The Food and Agricultural Economies of Tropical Africa: A Summary View," Food Research Institute Studies, Feb. 1961.

3. _____, Manioc in Africa (Stanford, Calif., 1959).

4. _____, "World Food Problems: The Nature of Our Ignorance" (Paper presented for Seminar on Optimizing the Use of Food and Food-Producing Resources in Economic Development, sponsored by The Center for Agricultural and Economic Adjustment Iowa State University, Ames, Ia., Feb. 19-23, 1962).

5. French West Africa, Organisme de Recherches sur l'Alimentation et la Nutrition en Afrique, Etudes monographiques de village: Kokoroue (manuscript, 1955).

6. Ibid. Sinorosso (1955).

7. Ibid. Issigui (1953).

8. French Equatorial Africa, Direction Federale du Service General Mobile d'Hygiene et de Prophylaxie, Sec. Nutr., Enquete nutritionelle dans le district de Madingo-Kayes (Moyen-Congo) (manuscript, Brazzaville, 1957).

9. Ibid. Mindouli (1957).

10. Ibid. Mossendjo (1956).

11. Nicol, B. M. "The Calorie Requirements of Nigerian Peasant Farmers," Brit. J. Nutr. (Cambridge), Vol. 13, 1959.

12. _____, "The Protein Requirements of Nigerian Peasant Farmers," Brit. J. Nutr., Vol. 13, 1959.

Discussion. The view was expressed that the dietary adequacy in Africa, inferred from the presentation, would hold true even if a modern society developed. Africa could produce her own food; the potential is very large. Her problems are now intensely economic. However, preferences for imported foods seem to develop readily. With economic development of the African countries, larger import purchases of food can be expected. Adequacy of the diet may decline temporarily, because consumption of leaves, wild game and foraged items may decrease.

Food balance data may be in considerable error. Statistics are almost nonexistent; there is a great weakness in lack of available information. Populations have not been estimated accurately, and there are differences from person to person, depending on income and other factors.

FOOD FOR INFANTS AND CHILDREN IN DEVELOPING COUNTRIES

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It seems appropriate that a stock-taking of the world's food needs and resources should be concerned with the special requirements of children in the developing countries. As previous speakers have indicated, infants and children (and one should include pregnant and lactating mothers) are the most vulnerable segments of any population to inadequacies or imbalances in the food supply. It is now being recognized more and more that prolonged malnutrition in infancy and early childhood may not only cause irreversible impairment to the health and mental fitness of the affected individuals, but also can be cumulatively detrimental to the overall vigor and productivity of a country's population. When physical and mental capacities are impaired, economic and social progress may be adversely affected.

Previous speakers have made it clear that protein inadequacy is a major nutritional problem facing the underdeveloped world today. There is no doubt that the aggravated death toll of children in tropical and subtropical areas is related to a lack of protein, both quantitatively and qualitatively. It is heartening therefore to observe the increasing recognition of this problem, as demonstrated by realistic appraisals such as this one today, which indicates the concern of governmental as well as international agencies.

In this connection, it may be recalled that in 1959, the General Assembly of the United Nations, in adopting a Declaration of the Rights of the Child, emphasized the importance of adequate nutrition, and stressed the role of UNICEF in providing practical assistance to governments to improve child nutrition. I shall direct my remarks therefore to the special interests and activities of the international agencies, specifically as represented by WHO/FAO/UNICEF Protein-rich Foods Program.

As is well known, the earliest preoccupation of UNICEF in child feeding was in the distribution of surplus dry skim milk, donated largely by the U. S. and also by Canada and Switzerland. This program will continue as long as such surpluses are available. This year UNICEF will supply 100 million pounds of dry skim milk powder to 100 countries. Of even greater significance is the continuing assistance of UNICEF to governments to equip and bring into operation milk conservation and similar dairy facilities, as has been done in 33 countries.

It has always been recognized that shipped-in milk powder used for relief feeding is an emergency response, although a very useful and necessary one, to a more deep-seated problem of protein scarcity in developing countries. This fact was dramatically emphasized two years ago by an almost traumatic international reaction to news that the U. S. surplus milk distribution program might be seriously curtailed due to lack of supplies. This form of assistance, as well as that for milk conservation to meet basic protein needs of infants and children, will continue to be major UNICEF preoccupations; nevertheless it is clear that such activities will fall far short of meeting the growing needs.

For these reasons, and also because of the strong desire of emerging countries to overcome protein deficiency by development and utilization of their own resources, the international programs are emphasizing a search for alternative sources of protein of good nutritive quality and low cost.

The primary responsibility for a solution will of course fall on agriculture, and intensive efforts are going on in many developing countries to expand the production of food staples of low to moderate protein content such as rice, wheat, maize,

and millet. However, crops which are notoriously low in protein such as bananas, plantains, sweet potatoes, and the ubiquitous tapioca (cassava/manioc) are also being called upon to meet growing food needs. Thus even as calorie deficiencies are narrowing, the protein needs of the world's expanding population are becoming more acute.

It is for these reasons that considerable interest is being directed toward protein resources previously used but little as human food, such as the oilseed meals and presscakes, and fish flour. Traditionally, the protein-rich residues of peanut, cottonseed, soy, sesame and copra have unfortunately been employed as frequently for fertilizers as for animal feedingstuffs. The proposal that they be utilized as foods for infants and children, notwithstanding the extensive literature on their feeding value for animals, prompted many questions particularly on the part of nutritionists and pediatric clinicians. These doubts to a large extent have now been dissipated as a result of a Rockefeller-assisted international research program administered by the U. S. National Research Council. The first report of 26 collaborators published last year indicates the remarkable value of plant protein mixtures in infant and child feeding, particularly when proper consideration is given to combinations of these products with each other and with local calorie-rich staples to effect the best possible amino acid supplementation. Practical feeding programs have already been initiated based on these and other clinical and nutritional studies, utilizing principally the oilseed protein residues.

One of the most hopeful prospects is wider utilization in new food forms of soy as a protein resource. In Indonesia, UNICEF and FAO have assisted the Government with the construction and operation of a plant to produce a spray dried extract ("milk") of soy and sesame, known locally as saridele, which is encountering an expanding demand. Much attention is being given to the development of useful food formulations for infants and children based on "toasted" soy flours, in countries such as Brazil, Taiwan, Japan, and Indonesia. UNICEF is also involved in research and development efforts to improve the technology of certain traditional fermented-type soy foods, including tempeh, a mold-processed product indigenous to Indonesia.

Peanut is another protein of considerable potential. UNICEF is currently assisting the government of India to bring into production the first commercial plants to provide edible peanut flour with protein content of 45 to 50 percent. The major utilization will be to supplement wheat flour and to provide a base for infant food formulations. In Nigeria peanut flour supplemented with skim milk (4:1) is being introduced, which has been shown to have almost the same nutritive and therapeutic value as skim milk itself. In Senegal, FAO and UNICEF are cooperating in the promotion of peanut flour supplementation of millet meal, the major local food staple. Brazil has a good potential for edible peanut flour, and this product has already been introduced into school lunch programs.

Suitably processed cottonseed flour is finding acceptance in food mixtures in Central America, based on the pioneering nutrition and food formulation efforts of the Institute of Nutrition of Central America and Panama. UNICEF and FAO are currently fostering food development and acceptability studies with cottonseed flour in Peru, Pakistan, Egypt, Turkey, and Iraq, which will hopefully lead to local production and expanded use of this protein concentrate.

The possibility of producing stable, bland, deodorized fish flours in various parts of the world to permit protein supplementation of caloric staples is now very real. As a result of much developmental activity during the past 5 years, several promising products are now available. UNICEF recently assisted the government of Chile to bring into production at the rate of one ton per day, a fish flour with protein content as high as 80 percent having excellent nutritive value. Much developmental work is also in progress aimed at production of protein concentrates from sesame, sunflower seed, and coconut.

The assistance provided by UNICEF and FAO to governments to further these efforts takes a number of forms, including not only the installation of production facilities, but also the training of scientists and technologists, the setting up of laboratories and pilot plants, and support of product development and market promotion efforts. At UNICEF headquarters the coordination of these programs requires continuous product quality testing, formulation of guidelines for product processing, and process development studies. Not overlooked is the possibility that frequently in developing countries, tradition, lack of knowledge, as well as social custom may contribute to poor nutrition practices even when useful food resources are available. For this reason UNICEF is providing increasing assistance to governments to disseminate among their people factual knowledge about nutrition. This involves increased emphasis on nutrition training for doctors, nurses, home economists and extension workers, as well as expansion of so-called community development schemes which include encouragement to increased local production and consumption of fish and poultry products, as well as fruits and vegetables.

By this time, however, I am sure it is obvious that a program which emphasizes the food utilization of certain products which in most societies have been considered at best as fodder and frequently as fertilizer, requires considerable adjustment in traditional attitudes, not only in the developing countries but also on the part of agencies seeking to introduce practices or solutions which may have been developed to meet the specific and frequently totally different needs of other societies or cultures. In a number of cases we are finding that neither traditional nor modern specialized processing and quality control concepts are useful without adaptation to problem-solving in these new non-traditional areas of food manufacture and formulation. In this work we seem to encounter surprises as well as new insights almost every day, which challenge our preconceived ideas. It is becoming clear that more knowledge is needed and new approaches must be devised.

A prevalent idea which bears re-examination is that almost any food surplus may be useful in meeting the expanding food needs of economically developing countries in the tropical and subtropical areas, and that it can be made attractive simply by changing its form. I do not wish to appear heretical, particularly at a meeting like this, but it must be obvious from what has been presented here today that food surpluses based on protein-rich materials such as the soybean may be more useful in many instances than the calorie-rich cereals, regardless of the form in which they may be presented. It may be wise to supplement them in processing in order to provide a qualitative as well as a quantitative contribution to the already calorie-rich but protein-poor diets of many developing countries.

An idea which seems to need much more emphasis is that while the concept of protein quality may not be critically significant in food-abundant countries amply supplied with animal protein, it may be a crucial matter in a food-needy country whose best resources of protein may be the cereals and the legumes. In our own protein-surfeited environment it really doesn't seem to matter much if many of our toasted breakfast foods and delectably crisp, sugared cookies have lower protein nutritive values than the ingredients from which they are made. Why worry since after all, our children eat them with milk!! There are cereal specialists here today who will bear out my observation, I believe, that the U. S. baking industry introduced dry skim milk into pan bread formulation before World War II, not primarily with improved protein nutrition in mind, but because it increased bread yield, promoted dough characteristics favorable to mechanical operations and yielded a loaf with softer crumb which stales less rapidly. As a cereal chemist I am acquainted with a great deal of excellent research dealing with the significance of the Maillard reaction in producing desirable colors and flavors in baked goods. In this literature, however, one searches almost in vain for the fact that in this process (as desirable as it may be from the point of view of food attractiveness and palatability), the availability of lysine, one of the most critical of the essential amino acids in

cereals, may be drastically impaired. It seems to me that a developing country subsisting largely on proteins of vegetable origin would need to examine critically those kinds of food processing which may be rational in protein-rich countries but which might be nutritionally deleterious for their own populations.

It is for these reasons, when examining the developing countries in terms of their specific food needs, that we who are involved with food processing and economics in the food-abundant countries must scrutinize some of the generally accepted concepts and practices with great care and objectivity, if not indeed humility, before we prescribe them for the peoples of the developing countries of the world.

Discussion: Discussion centered around values of available high-protein supplements. Palm-kernel meal was reported to contain about 25 percent protein but to be deficient in lysine, tryptophane, and methionine. Dried whole milk was considered superior to dry skim milk for feeding children if it could be packaged and kept properly. Soy and fish flours, synthetic lysine and other supplements would be considered in combination with wheat if acceptability, cost, and technology were satisfactory. More information is needed to permit quality evaluation of bread containing fish flour.

The fish flour from Chile is made from whole fish, the only economic way at present. Some 15 production runs have yielded a product with 6-8 percent lysine and a protein efficiency ratio of 2.6 - 3.0.

Considerable interest is also evident, for several reasons, in the use of full-fat soy flour. It would make an excellent addition to the manioc diet found in Brazil, for instance, but marketing procedures make this difficult.

THE PATTERN OF TRADE IN FOODSTUFFS

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The nineteenth century pattern. In the latter part of the nineteenth century and right up to the great depressions that followed the first world war, world trade in foodstuffs was dominated by the United Kingdom. This was the largest, freest and most rapidly growing market in the world. It was also the center of the organized marketing, shipping, credit, and investment facilities upon which the trade depended. After the Corn Laws were repealed, population grew very rapidly and more people crowded into the industrial towns. Domestic agriculture and particularly grain-growing could not compete with the flood of cheap grain produced by extensive mechanized methods on virgin soils. Freight rates fell steadily as railroads opened up the interior plains in both temperate zones and tramp steamers competed with windjammers for bulk cargoes. The most important agricultural implements invented in the 19th century were the steam locomotive and the steam ship. The United Kingdom supplied the capital for the railroads, developed the ships and organized the great produce exchanges. But above all it bought the grain.

This was a highly efficient marketing system. Because there was a large free market, prices did not differ between the main consuming centers by more than a small differential. National agricultural policies had not then split the markets into insulated fragments where prices differed by multiples rather than fractions. Moreover, prices were more stable over time than they became during the interwar years of depression and disintegration. They have since been stabilized by international agreement but only for that shrunken part of the trade covered by the agreement. The success of these stabilization agreements at the cost of killing or at least maiming the trade always reminds me of the medical man who claimed that the operation was a success though the patient unfortunately died.

Under this free marketing system, world trade in foodstuffs quite literally "called a new world into existence to redress the balance of the old." In the eighty years after the repeal of the Corn Laws the tonnage of wheat that entered into world trade increased tenfold. This flood of grain poured in from many lands, near and far, but it came primarily from the New World countries. By the time the flood reached its crest, just before the great depression of the 1930's, no less than 85 percent of the wheat entering world trade came from the four principal suppliers--the United States and Canada, Argentina and Australia. Exports from the traditional European sources of supply--Russia, eastern Germany and the Danubian plain--had shrunk as a result of war and revolution, both absolutely and relatively. There had been a spurt of exports from India in the 1880's; but the massive increase in supplies had come from the efficient mechanized farming of the New World.

There was indeed a very clear trend for the trade in wheat to pass from the United States to even newer centers of production in Canada, Argentina and Australia. The great decade of wheat exports from this country was the 1880's when the virgin soils of the interior plains were opened up by the railroads and cheap freight moved the crops across the Atlantic. But as the United States grew in population and industrial strength it lost some of its comparative advantage in wheat. In the late 1880's it had provided 35.8 percent of world exports, but by 1909-13 its percentage had dropped to 14.5. Canada, Argentina, and Australia could produce wheat for export more cheaply.

The situation was changed, and the first wheat surpluses of modern times began to develop, as a result of the campaigns undertaken to increase production during the

first world war. By 1924-8, the United States' share of world wheat exports had risen to 22.1 percent; but Canada's had risen to 35.2 percent, Argentina's to 16.8 percent, and Australia's to 10.6 percent.

PERCENTAGE DISTRIBUTION OF AVERAGE ANNUAL WHEAT EXPORTS (GROSS) BY COUNTRIES, 1854-1858 to 1952-56[1/]

Country	1854-58	1884-88	1909-13	1924-28	1934-38	1952-56
United States	24.9%	35.8%	14.5%	22.1%	8.0%	33.5%
Canada	6.4	1.2	12.6	35.2	27.9	31.3
Russia	12.0	25.3	22.3	2.1	4.2	2.6
Danube Countries	9.8	18.6	15.8	4.2	7.6	1.1
Argentina	--	1.4	13.2	16.8	19.3	8.8
Australia	--	2.4	6.9	10.6	16.4	9.8
India	3.2	10.1	7.1	2.1	1.6	--
Other	43.7	5.2	7.6	6.9	15.0	12.9
Total	100.0	100.0	100.0	100.0	100.0	100.0
Metric tons (000's)	2,544	9,500	19,696	23,852	17,332	27,142

1/ Robert M. Stern, "A Century of Food Exports," Kyklos, Vol. XIII, Fasc. 1, pp. 44-64.

It was these war-induced increases in production and trade that destroyed the free marketing system. The United Kingdom abandoned its free-trade policy and was no longer able to finance world trade and investment. Trade restrictions and exchange controls became almost universal during the great depression of the 1930's. What took the place of the free market was a series of controlled and separate markets (between which prices diverged widely). These were linked precariously by a succession of international wheat agreements. The burden of adjustment fell inevitably upon the major efficient, low-cost producers. The decade of depression in the 1930's therefore witnessed a painful contraction of supplies from Canada and the United States and a smaller contraction in Argentina, though Australia increased its exports, relatively and absolutely.

The second world war brought an exaggerated repetition of these experiences. The United States' share of world exports which had fallen to 8 percent in 1934-8, was no less than 33.5 percent in 1952-6 and Canada's share had increased also to 31.3 percent. So far we have not had a repetition of the depressions that followed the first world war. The market has not been freed. There has instead been a continued increase of these North American surpluses, supported by guaranteed prices. A large share of world exports now proceeds by various subsidized devices, and the burden of contraction has therefore shifted to the lower-cost producers in Argentina and Australia. With the advent of a common agricultural policy in the European Economic Community, and the probable inclusion of the United Kingdom within that Community, it seems inevitable that there must be further contraction of exports from the main exporting areas. This is a major reason why Canada and Australia have opposed

Britain's entry into the Community. But the device of import levies amounting to the differential between the Common Market and world prices, to be used to encourage increased production within the Common Market, is bound to have a considerable impact also upon wheat-growing within the United States. It raises very large policy issues concerning the continuation of subsidized production and the accumulation of surpluses, and also concerning the use of P. L. 480 to subsidize wheat exports. The United States must either abandon the costly and ineffective effort to control production and sustain prices, or it must develop much further its use of food surpluses to achieve primarily political purposes.1/

The impact of technology. Before this audience of agricultural experts, there is no need to go further with these summary historical statements. Already many of you will have formulated questions, qualifications, and additions and corrections to the categorical and dogmatic statements that have been made, but my purpose was not to present a conclusive analysis of the recent past. It was simply to remind ourselves that there is a historical background to our present dilemmas. We do not start with a clean slate. People have migrated and populations have grown, investments have been made, and standards of living have been set as a result of past production and trading patterns that are now disintegrating. To explore this background adequately, even for wheat, would require many volumes by many specialists. Tonight all I can do is to select some of the issues that seem to be raised by changing technology, by changed political groupings, and by new trade policies.

There are different backgrounds for other grains, particularly corn. The feed grains should indeed be treated as instrumental rather than consumption goods. Largely because of abundant and relatively cheap feed grains, poultry production in the world is now greater than that of mutton and lamb. New scientific discoveries have played a large role on the supply side. The development of hybrid corn has indeed become a symbol of the new technology in agriculture.

The complex relations between the various sources of fats and oils, vegetable and mineral, for industrial and edible use, are complicated by technological innovations that affect demand as well as supply. The impact of such technological advances in industrial demand as well as agricultural production upon future trading prospects offers a tempting field of speculation; but all I can do at this time is to note the fact that the newer phases of the modern scientific revolution will have profound effects upon agricultural, as upon all, production and trade.

As the 19th century drew to its close, new foodstuffs made their appearance in world trade. From the early 1880's the livestock producers of the New World were able to chill or freeze meat and butter and cheese for distant markets. The earlier techniques of canning were improved and extended to meat and fish and later to fruits and vegetables. The United States was a pioneer in many of these developments and has maintained its leadership in the export of dried and canned fruit and vegetables. The even newer methods of juice concentration, dehydration, deep-freeze, and quick-freeze have not yet been extended very far beyond the borders of the United States; but it seems obvious that there will be a rapid development of such methods in other countries. Whether transport facilities can be developed to make possible world trade in the food preparations on which the American housewife increasingly relies seems very doubtful. The food processing industries of the United States may find it necessary to export their techniques through direct foreign investment, rather than apply their research and development efforts to the transport problems involved in exporting the finished product.

1/ Joseph S. Davis "Food for Peace," Food Research Institute Studies, Vol. 1, No. 2, May 1960; and Helen C. Farnsworth "The Problem Multiplying Effects of Special Wheat Programs," American Economic Review, May 1961.

What does not seem to be doubtful is that the older methods of food preservation and transport can hardly hope to extend or even maintain their overseas markets. The newer methods can and will be developed locally as economic development proceeds and the necessary equipment is installed by local enterprise or by direct foreign investment. It is tempting to speculate that, as the production and preparation of foodstuffs comes to depend more upon technology and less upon the vagaries of nature, it will become more like other forms of manufacturing. Its location will move away from such natural factors as climate and water in order to be closer to the market. There will be relatively less export of finished products such as frozen meat and butter and much greater exports of raw materials such as feed grains, oil cake, and fertilizers. Food production will become a new sector of the branching chemical industry. Exaggerated and fanciful as such speculations may seem, they may at least serve to remind us that what nylon did to silk and paper to jute may be paralleled by new technical advances in the arts of food production and food processing.

Political markets. In world trade, refrigeration became important to the southern hemisphere livestock producers. This trade is now greatly changed. What has happened in Argentina is an example of political rather than economic determination of trading patterns. Many other food products also illustrate the dominance of politics. At least since the Sugar Convention of 1882 the sugar market has defied any rational analysis based on production costs and market demand. The wheat market has been in the same situation for at least the last thirty years. Dried milk, and dairy products in general, have also become political instruments rather than economic goods and many other cases could be cited.

In retrospect it now seems clear that the closing of Argentine markets in Britain during the early 1930's foreshadowed what may happen to other New World countries. It is possible, for example, that the Common Market countries may prefer to import feed grains and oil cake to fatten their own livestock rather than import chilled or frozen meat from overseas. The nineteenth century system whereby Europe absorbed ever-increasing quantities of wheat, meat, dairy produce, and processed foods from the efficient, mechanized farming areas of the New World may be drawing to a close. The lowest cost producers, such as the New Zealand butter producers, could certainly maintain and perhaps even extend their sales in the great industrial markets including the United States if they were given free access to them; but they have no access at all to the United States market and seem likely to have restricted access in future to the Common Market (including the United Kingdom).

The pattern of world trade in the future cannot, therefore, be projected simply by extrapolation of past trends or by analyzing the impacts of new technology. It will be determined in large part by political rather than economic decisions. Already, under P. L. 480, the United States is exporting food-grains not simply to meet current consumption needs, but to build reserves in many countries against emergencies. These exports are subsidized by the American taxpayer. The local currencies received for them begin to cause concern to governments both of the United States and of the recipient countries. As population increase continues, these American surpluses become more essential in the countries of food shortage. What will happen to their economies if the United States ever decided to stop paying to produce these surpluses and distribute them around the world? There are many who will argue that this is unthinkable because of the powerful combination of mercenary and missionary motives that coalesce in such programs as "Food for Peace." But if such motives continue to dominate the world trade in foodstuffs the economist will have little to say about its development.

Let me pause to illustrate what I mean. At the moment the possibility of selling wheat to China presents a policy problem to the United States. For many years now we have refused to recognize the Communist government of mainland China or to permit any trade with it. A large and strong body of public opinion supports this uncompromising attitude. On their side the Communist leaders in China have built up the

United States as an imperialist bogeyman. We have our quarrels and our deep underlying conflict with the Russians; but at least we talk to them and, within limits, we even trade with them. Our attitude to the Chinese and theirs to us is much more hostile--we won't talk to them or trade with them and we refuse even to recognize their existence as a government.

There is a minority view, held mainly by Quakers and some churchmen, that it is our Christian duty to feed our enemies and to love them that despitefully use us. But if we regard this as an act of Christian charity we should not expect reward or thanks, still less political or military advantage.

In support of the view that it is our moral duty without expectation of reward to share our abundance with the hungry people of the world, there is a calculating school of thought that argues we shall do well by doing good. Those who feel this way insist that if we give or sell wheat to China we should see that the Chinese (and everybody else) give us credit for doing so. We cannot mark each grain of wheat, grown in the U. S. A., but we should mark the ships and the sacks and advertise, especially to the other Asian peoples, that it is our wheat that is going to China. If we withhold food from starving people, the Communists will certainly trumpet this fact not only throughout Asia but throughout the world. Whether this will do us much harm in the long run is not very clear to me. It would seem possible for us to ask why the Russians don't accept the responsibility for taking care of their Chinese allies. On the other hand, I doubt whether we will get much credit for generosity in China itself or elsewhere in Asia. Gratitude is not a marked feature of international politics. In my judgment, the propaganda value of giving or withholding food is difficult to measure and ought not to be a decisive factor in our policy.

Some strategists go further and argue that food can be a decisive weapon in the cold war and that we should use it as such, feeding our friends and starving our enemies. They can point to the decisive influence exerted in both world wars by naval blockade. There is no doubt also that agriculture is the weak spot in the economy of both Russia and China.

It is tempting to believe that by withholding strategic materials and especially food, we can at least complicate communist strategy and perhaps hasten the ultimate collapse of these communist regimes. Apart from the fact that such a policy runs counter to our American tradition, success would require the cooperation of our allies so that the blockade would become effective. No doubt those to whom the crusade against communism is a holy war could argue that, successful or unsuccessful, we should never lose an opportunity of weakening the enemy. This is just as logical an attitude as the Christian attitude of never losing an opportunity to demonstrate that we are ready to love even our enemies. But the population of China is probably now more than 700 millions. It seems highly improbable to me that any giving or withholding of food to such numbers can be of more than marginal significance. If the communist regimes, either in Russia or in China, were on the point of collapse, it might be worth considering whether a little more starvation might not bring the collapse more quickly; but one needs to be more optimistic than I am to believe that collapse is imminent or even likely. Distress and discontent there is no doubt; but the communist leaders have strong wills and cold hearts and are not moved as we are by the sufferings of their people. So I conclude that we should not expect to gain or lose decisive military advantage any more than we expect to gain much propaganda advantage from our food policy. If we could find an effective way to use our food surpluses so as to weaken the Russian or the Chinese regimes, or to drive a wedge between them, I shouldn't hesitate to use it; but there seems to be just as much chance of achieving this by supplying the food as by withholding it.

What remains then to decide? A very wise friend--one of the founders of the Stanford Food Research Institute, Carl Alsberg--used to say that when one is in a difficult situation, it is nearly always better to act natural than to act smart. My own impulse would be to let the Chinese buy some of our surplus wheat if they ask for it and are prepared to pay the market price for it in an acceptable currency. We don't need the wheat and we do need the foreign exchange or gold. They should ask for it and trade openly. I see no reason why we should give them the wheat or extend credit beyond the usual commercial terms. They have bought goods from the British with silver bullion and from other countries with gold. We should also be paid. Their loss of foreign purchasing power would then weaken their military capacity. If they must buy food, they can't buy strategic materials. Whether it would weaken them as much as prolonged starvation it is not possible to say.

This is my own personal view. There will be many who disagree, even if they accept the fact that the balance of propaganda and military advantage is not decisive. It will be argued that to permit any trade, or indeed any contact, with Red China will open the door to recognition, that we have stood firm for fourteen years and should not weaken now, that the vote in last year's Assembly of the United Nations showed that our attitude of nonrecognition has more support than most of us had dared to hope and that we should not sell out either from pity for the starving Chinese or in order to get rid of an embarrassing wheat surplus. This view is sincerely held and is probably the view of the majority of U. S. citizens and their Congressional representatives.

I do not criticise it; but I think we should be clear on three points. First, it is ultimately based on the premise that refusal to sell strategic materials and food to the communist countries will weaken them and ultimately bring them down. This premise has not yet been borne out by the facts. The second point is that for a boycott to work we must close off alternate sources of supply and this we have been unable to persuade our allies to do. Finally, our refusal to supply equipment to China is one of the factors that keeps them dependent on the Russians and despite growing conflict and strain, helps to maintain the Soviet-Chinese alliance.

Who exports foodstuffs? One reason why I have ventured to remind you of the historical development of the 19th century trade in foodstuffs, is that it is essential to clear away some of the confusion that has prevailed in recent discussions of world trends in production and prices. As in so many other aspects of agricultural policy, there are strong emotional assumptions that obscure the statistical facts. The case for agriculture is argued in terms of hard-working farm families cultivating small holdings and, in Falstaff's phrase, "larding the lean earth with their sweat." The surpluses that vex commodity markets, however, are produced on large, mechanized farms by modern business men or even corporations, who substitute chemical fertilizers for sweat. The terms of trade for agricultural products, the alleged inadequacy of world demand for food and agricultural materials, the sagging prices and accumulating surpluses of farm staples are argued in terms of rather primitive and very poor developing countries. But in fact the poorer countries of the world have little food to export. Countries with the highest living levels produce the great bulk of the food traded on world markets. For all exports of cereals (including the rice of Burma and Thailand) the underdeveloped countries accounted in 1958 for only 15 percent.

The overwhelming bulk of the foodstuffs that enter into world trade are produced in the already developed and highly mechanized countries, using advanced technology. The main exception to this broad statement is to be found in the rice-surplus areas of southeast Asia; but one of the less pleasant facts that emerges from a study of world trade in recent years is the steady disappearance of food exports from one country after another, and the emergence of imports. The underdeveloped

countries are clearly moving towards deficits that must be made up by imports of foodstuffs from the already developed countries. Because of the uncontrolled increase in their populations they become more, rather than less, dependent on food imports.

It has already been suggested that this fact implies fateful decisions for agricultural production and export policies in the surplus-producing areas. It has even more important implications for agricultural policy in deficit, developing countries. With increasing numbers, the need for food will increase beyond the capacity to produce it by traditional methods. This is as true of the Masai in Kenya as it is of the West Indians, the Saudi Arabians, the Iranians, Indians or indeed any but a very small group of nations in relatively underpopulated and fertile areas such as Burma, Thailand, and perhaps Indonesia. Even in regard to rice, however, the competition of advanced forms of agriculture, particularly in the United States, has been severe so that prices have fallen. As with another traditional Oriental product, soy beans, the growing production of the industrialized agriculture is making it more difficult for Far Eastern producers to expand production to keep pace with their growing population. One way to meet the food deficit in developing countries at least temporarily is by imports, but in most cases the individual consumer does not have the purchasing power to buy expensive foods and the economy as a whole lacks the capacity to earn by exports the foreign exchange needed to pay for imports. This is why imports are given or lent or sold at reduced prices by the surplus countries.

Food policy in the developing countries. Quite obviously the best way to meet these growing food deficits would be to increase the productivity of agriculture in the deficit developing countries. Considerable efforts have been and are being made in many countries to achieve such productivity increases. Members of this conference were among the team of experts that worked out a comprehensive plan of attack upon the problem in India. The Ford Foundation is now engaged upon a large-scale demonstration of the methods proposed by this expert group. Impressive results are being achieved in the demonstration districts, but the task of extending these methods all over India, by Indian technicians and Indian initiative and through Indian governmental services has still to be faced. The United States has established what is in essence a Food Reserve Bank to tide over interim emergencies. Meantime the geometric increase of population continues. The Ford Foundation initiative in India is a gallant effort and deserves success but it is still too soon to form any clear estimate of the outcome. There is little doubt that by sustained maximum effort even the tremendous population pressure on limited food resources in India could be met--the question is whether the maximum effort will or can be made.

All over the developing world there is need to organize efforts comparable to that being made in India, to mobilize first the planners and then the executants of a plan, but above all to transfer both their expertise and their drive to the local community. No one who has ever tried is likely to disagree that the drive is both more important and more difficult to transfer than the expertise.

It should be said, however, that in the long run even the best conceived and executed plans to increase agricultural productivity will fail if they are directed solely to satisfying local food needs. Unless some exports can be developed to provide the foreign exchange necessary to purchase vital imports or equipment and materials, the economy will not become self-supporting let alone self-generating. It is an unfortunate fact that not only the planning officials in the developing countries, but the economists on whose theories and models they rely, have too often neglected or even belittled the role of exports in development.2/ In their eagerness to

2/ K. Berrill "International Trade and the Rate of Economic Growth," Economic History Review, Second Series, Vol. XII, No. 3, and A. K. Cairncross, "International Trade and Economic Development," Kyklos, Vol. XIII, Fasc. 4, 1960.

develop, these economies push expenditures to the verge of inflation, raising production costs and making import controls necessary. The traditional export industries were often foreign-owned and tagged with colonialism. Too often they have been hampered by tax burdens intended to divert their profits to development. Sometimes the effect of such taxes has been disastrous, as when India imposed an export tax on jute and lost a large part of the world market permanently to paper and other fiber containers.

Up to this point the argument has been concerned with staple foodstuffs produced in temperate regions. Nothing has been said about the products of tropical agriculture. This was for two reasons. First, the surplus foods that enter into world trade, with the notable exception of rice, are temperate products. They are the main resource for coping with the massive population increases and the economic aspirations of the developing countries.

In the second place, it is upon these commodities that the argument concerning prices has been concentrated. The first calculations, purporting to show that for many decades agricultural prices have lagged behind those of industrial goods so that the terms of trade moved rather steadily against agricultural exporting countries, have been shown to be unconvincing.[3/] In particular they omitted the vital element of falling freight rates.[4/] Not so much is heard of this argument since these facts were pointed out, but it is still maintained that demand for the products of temperate agriculture has not kept pace with the needs of the developing countries for imported equipment. The calculations of GATT, from which this argument is derived, depend on the way in which countries are grouped as industrial or non-industrial. It could be argued, however, that Australia and New Zealand, South Africa, and Argentina are at least as industrialized as Iceland, Ireland, Denmark, Greece, Portugal, or Turkey. Not much in fact is to be gained from analysis in such groupings and in any case the prices and terms of trade for temperate foodstuffs are a matter of concern for the industrialized food exporters, not for the developing countries. In fact, except for the recent depressions, they have done very well in the years since the war ended.

It is not suggested even by the proponents of this thesis, that tropical agriculture (rice and coffee excepted) has suffered from perverse price movements in the postwar period. Terms of trade have not been bad for cocoa and palm oil, sugar and dates, bananas and pineapple. It is not new knowledge that in cyclical depressions, agricultural and mineral prices fluctuate more violently than the prices of manufactured goods. There is no convincing evidence that longer-run price trends or industrial demands have moved against food products or for that matter agricultural raw materials. There is, however, much evidence that with the rapid advances of technology, the old types of agricultural production and marketing, wherever they are practiced, cannot compete with the new methods which naturally have been developed in industrial countries. Plant and animal breeding, including irradiation to produce mutations, plant and animal nutrition, food processing and preservation, standardization, grading and quality control, packaging and above all marketing techniques are in process of rapid change. Modern methods of mass production and mass merchandising make it almost impossible to use odd lots of merchandise of variable quality. The cotton grown in California is a standardized variety and the bushes grow to a uniform size, so that mechanization can be used to replace expensive hand-picking. The baled product is as uniform and as clean as any other commodity manufactured under precise controls.

3/ P. T. Ellsworth, Journal of Inter-American Affairs.
4/ Carl Major Wright, Economic Journal, Sept. 1955, Vol. LXV, "Convertibility and Triangular Trade as Safety Against Depression."

The sequestration of plantations and reversion to peasant agriculture, for example in Indonesia, can be understood, but such actions cannot but hinder the adaptation of the developing countries to the new market demands. There is less surplus for export when production is organized in small units. This is clear even in the USSR. The peasant is apt to consume more of what he produces. It is much more difficult, even through cooperatives, to control the quality of his output so as to assemble standardized and graded products in sufficient volume to warrant export. Packaging and processing are more difficult than in a plantation-factory system under competent technical management. It is the obsolete production techniques of the underdeveloped countries, not demand or prices in the industrial countries, that is responsible for the lag in exports from the underdeveloped areas.

INTRODUCTION--SESSION ON NUTRITIONAL VALUES OF WHEAT

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As stated yesterday, the primary object of this conference is to develop a factual picture of the problem of world need for food and how wheat can be used to best advantage in meeting that need. When I say "best advantage" I mean the best advantage of this country in its humanitarian and long-range profit objectives and also the best advantage of the peoples of the underdeveloped countries. Yesterday Dr. Johnson ably laid the groundwork by giving us a broad picture of world food needs. We had all known that a great need exists for both calories and protein but this Economic Research Service work gives dimensions to the problem and points to opportunities to develop markets for wheat.

We also heard much about specific areas of the world which, for economic and political reasons, offer the greatest possibilities for wheat usage--Free Asia, Latin America, and Africa. Dr. Hand, Dr. Bressani, and Dr. Jones told us about the types of foods consumed in these areas, how much of these foods are available, and about some of the problems which must be overcome if we are to achieve our objectives. Dr. Milner spoke on the special needs of infants and children.

We have heard a lot about underdeveloped countries and of nutritional deficiencies in them. I recall a brief article in the Journal of the American Medical Association about a year ago. It was entitled "Longevity in Hunza Land." A few quotations from this article follow:

"This little-known frontier land in northern Pakistan has a population not greater than 25,000. It lies northeast of the famed Khyber Pass, with USSR and China for neighbors....

"The evidence that Hunzakut males live to be 120 or even 140 years of age is not documented with reliable vital statistics. Such ages are believed to be within the limits of possibility, however. A steady upgrading of longevity in the Occident may reach the reputed longevity of selected peoples in the Orient, popularized initially by Hilton's 'Lost Horizon'.... The latter (Hunzakuts) have little animal protein, few eggs, and no commercial vitamins. Their diet consists of whole grain (wheat), fresh fruit, fresh vegetables, goat's milk and cheese, rice and grape wine. The men are reported to be fertile in the ninth decade of life, but this phenomenon also is not documented."

If these reports are true some of the underdeveloped countries may not want to develop at least to an animal type agriculture. Our objectives of shipping wheat, however, would be in accord with good Hunza tradition.

In order to make a food market development program a success, it is essential that the product have high nutritional value and that the person who is expected to purchase the product know that the product is good. A great deal of misconception is prevalent concerning the nutritional value of wheat, and the wheat "image" in the public mind is not all that it should be. Wheat is certainly not a complete food in itself, but neither are any other single plant or animals products, including milk, meat, soy beans, and fish. Properly used, all are good nutritious foods. For this morning's session we have assembled a panel of outstanding nutrition experts who will discuss several aspects of the nutritional properties of wheat.

RECENT RESEARCH ON NUTRITIONAL QUALITY OF WHEAT PRODUCTS

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Most investigations on the nutritional quality of wheat have been concerned with Triticum aestivum and for this reason, unless otherwise stated, the data reported here will pertain to this species. However, available data concerning specific nutrients for samples of club and durum wheat indicate values which fall within the ranges published for common wheat.

Historical usage of wheat as the major component of the diet of large population groups indicates that wheat must contribute materially to man's nutrient requirements. However, as the science of nutrition has developed, each new discovery has outweighed the last, and foods which were outstandingly good sources of the most recently discovered nutrient gained the limelight. Cereal foods, including wheat, because they are not concentrated sources of any single nutrient, were eclipsed by foods for which dramatic advertising claims could be made. Demonstrated losses of nutrients due to cereal processing and, particularly, losses which resulted in frank nutritional deficiency disease constituted the coup de grâce for cereals in the minds of many people.

Because current emphasis in nutrition is on protein and because of the numerous efforts being made to develop new concentrated sources of high-quality protein, it seems appropriate to start this discussion with a presentation of data on wheat proteins and their amino acid composition.

The protein content of wheat ranges from 7 to 20 percent or more. Soft wheat varieties with low-protein content are purposefully grown because flour produced from such varieties is best suited for the manufacture of cakes, pastries, etc. Hard wheat varieties with high-protein levels are grown because the flour milled from them is best suited for the manufacture of yeast-leavened bread. The protein content of wheat, however, depends upon more than varietal differences. Climate, soil type, and fertilization markedly affect wheat's protein content, and varieties which produce a protein content of 14 percent in certain areas may yield as little as 8 percent in areas of greater rainfall.

More data are available concerning the amino acid composition of the protein of hard wheats than are available for soft wheat samples. Some of these data have been gathered in the hope that variation in levels of individual amino acids may give a clue to variations in baking quality. Although these data were gathered to solve technical problems, they have contributed useful information to nutritionists. Hard wheats have been investigated more frequently than soft wheats by those interested in nutrition because they are the source of flours for the manufacture of bread which is considered important to man's nutrition, while soft wheats are the source of flour for the manufacture of sweet goods which are prized as confections.

Typical values for the essential amino acids in wheat, flour, and bread are given in Table 1 (1). These are average values for commercial hard wheat blends, the flours commercially milled from these wheat blends and the bread produced from these particular flour samples using a typical American formula requiring four parts of nonfat milk solids for each 100 parts of flour. We have found a very narrow range of values for the individual amino acids in bread wheats. Data reported from other laboratories in the United States, England, and Belgium (2,3,4), show no significant differences from these values.

Table 1. Essential amino acids in wheat, flour, and bread
(Grams per 16 g. nitrogen)

	Wheat	Flour	Bread
Arginine	4.69	3.80	3.56
Histidine	1.92	1.88	1.89
Isoleucine	3.90	4.26	4.32
Leucine	6.48	6.98	7.11
Lysine	2.74	2.08	2.48
Methionine	1.76	1.73	1.90
Phenylalanine	4.42	4.92	4.80
Threonine	3.02	2.82	3.01
Tryptophan	1.09	1.02	0.97
Valine	4.50	4.54	4.68

Flours used in obtaining these figures represented 80 to 96 percent patents from flour milled at extraction rates ranging from 72 to 75 percent. This means that in the case of the least refined flour, 72 pounds of flour were obtained from each hundredweight of wheat, and in the case of the most highly refined flour, only 58 pounds were obtained from each hundredweight of cleaned wheat.

It is to be noted that milling wheat into white flour results in significant loss of several of the amino acids. Most interest has been created by the 30 percent loss of lysine because this is known to be the limiting amino acid in wheat protein. We have been unable to find any significant difference in the amino acid composition of the protein of the most highly refined and least highly refined white flour. In other words, once white flour is produced the diversion of the poorer quality streams does not cause a further reduction in the level of any of the essential amino acids.

Table 2. Nonessential amino acids in wheat, flour, and bread
(Grams per 16 g. nitrogen)

	Wheat	Flour	Bread
Alanine	3.25	2.78	2.93
Aspartic acid	5.09	4.14	4.60
Cystine	1.97	2.11	1.88
Glutamic acid	28.50	34.50	31.70
Glycine	3.88	3.22	3.21
Proline	9.85	11.70	11.10
Serine	5.06	5.44	5.45
Tyrosine	3.10	3.25	3.32

The nonessential amino acids are given in Table 2. Wheat is characterized by its high glutamic acid and proline levels. More will be said about glutamic acid later.

Differences in amino acid composition of the proteins of wheat and the proteins of white flour indicate a concentration of some of the amino acids in the proteins of the fractions removed in the milling process. Table 3 (5) gives the essential amino acids found in patent, first-clear, and low-grade flours and red dog. The similarity in composition of the protein from patent flour and from first-clear, explains the uniformity of composition of the proteins of long and short patents. Patent flour results from diverting the less refined flour streams which are then packed as clear flour. The low grade and, particularly, the red dog, have quite a different pattern

Table 3. I. Concentration of amino acids in products of Mill A
(Gram per 16 g. nitrogen)

	Patent flour	First-clear flour	Low-grade flour	Red dog
Arginine	3.73	3.87	4.68	6.84
Histidine	1.92	2.06	2.14	2.22
Isoleucine	3.91	4.02	3.72	3.42
Leucine	6.63	6.59	6.33	5.77
Lysine	1.97	1.94	2.54	4.13
Methionine	1.73	1.71	1.67	1.70
Phenylalanine	4.77	5.04	4.64	3.55
Threonine	2.64	2.73	2.76	3.11
Tryptophan	0.92	1.01	1.01	1.25
Valine	4.32	4.44	4.45	4.91

Table 4. II. Concentration of amino acids in products of Mill A
(Gram per 16 g. nitrogen)

	Shorts	Bran	Germ	Whole wheat
Arginine	6.85	6.60	6.88	4.71
Histidine	2.20	2.22	2.26	2.12
Isoleucine	3.31	3.29	3.48	3.78
Leucine	5.64	5.51	5.75	6.52
Lysine	4.18	3.77	5.28	2.67
Methionine	1.62	1.48	1.91	1.74
Phenylalanine	3.44	3.58	3.38	4.43
Threonine	3.03	2.86	3.42	2.76
Tryptophan	1.29	1.58	0.98	1.13
Valine	4.84	4.69	4.90	4.69

of amino acid composition from the white flour. The red dog proteins, for instance, contain twice as much lysine as is found in the proteins of the white flour fractions. Table 4 gives the essential amino acid pattern of shorts, bran, germ, and the wheat from which each of these fractions was derived. It is to be noted that the lysine content of the shorts, bran, and germ is substantially higher than the lysine content of the whole wheat. Threonine and, to a lesser extent, tryptophan, follow the same pattern.

This distribution of amino acids in mill fractions suggests the possibility of an economical production of custom-made wheat foods to match the particular demands of different age groups. Gruels for the very young could be made from the shorts and low grade which would satisfy the higher protein and lysine requirement of weanlings. Products made from white flour, when they constitute a substantial proportion of the diet, furnish adequate quantities of amino acids to meet the requirements of older children and adults. On a 14 percent moisture basis 100 g. of shorts, for instance, would furnish 0.75 g. of lysine compared to 0.24 g. of this amino acid furnished by 100 g. of white flour.

The availabilities of the eight amino acids essential to man have been determined with weanling rats of the Sprague-Dawley strain. To do this it was necessary to design a basal diet (6) containing amino acids as a sole source of nitrogen. To determine the availability of a particular amino acid, increments of the amino acid

under study were employed in the basal diet to provide a standard curve. To the basal diet containing a suboptimal amount of the same amino acid, known quantities of wheat, flour, or bread were added at the expense of starch. The increment in growth caused by the addition of wheat, flour, or bread provides a rat assay value for the amino acid being studied. Percent availability was calculated using the formula:

$$\text{Percent availability} = \frac{\text{amino acid found by rat assay}}{\text{amino acid found by microbiological assay}} \times 100$$

Carcass nitrogen gain plotted against available amino acid consumed gave a straight-line relationship over most of the standard curve as is shown in Figure 1. This

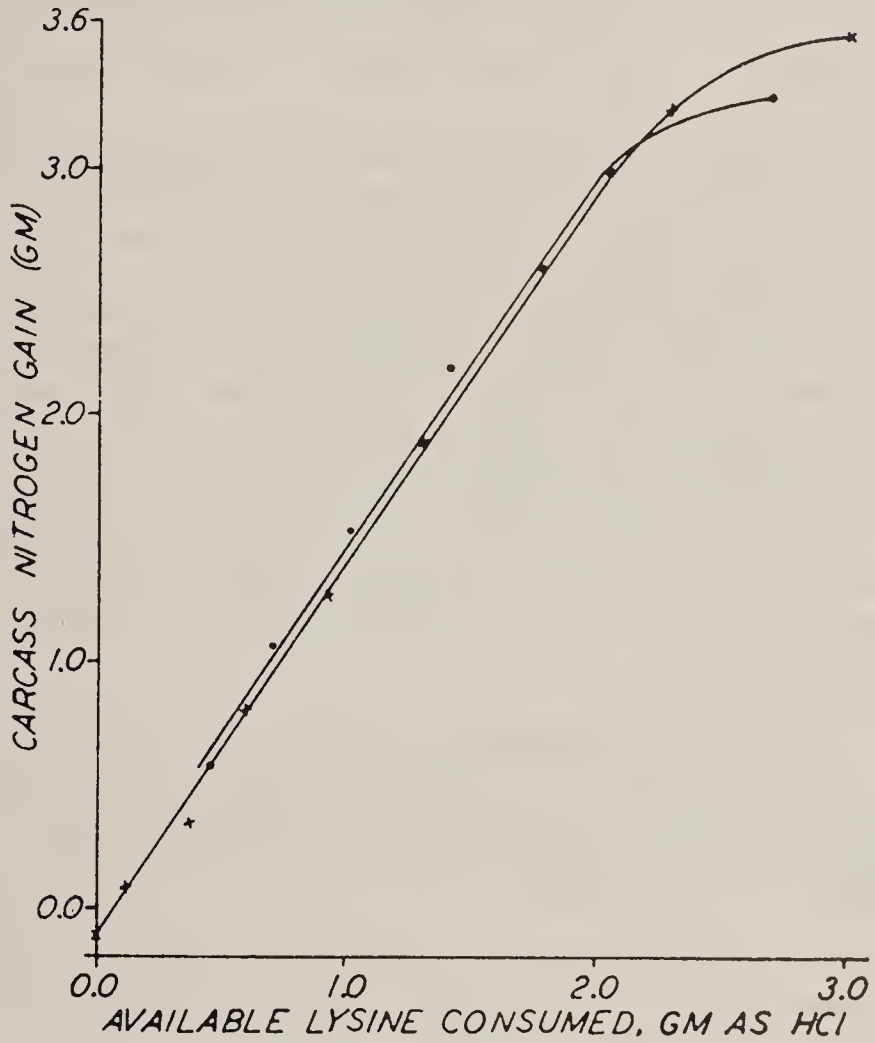

Figure 1. Carcass nitrogen gains of rats on basal A(dots) and basal B(crosses) diets vs. available lysine consumed.

figure shows two curves: one made using the basal diet containing no natural protein sources, and the other made using a basal diet which contained 20 percent wheat gluten. That these curves are essentially the same, except at very high lysine levels, demonstrates the effectiveness of the amino acid mixture as a replacement for protein in the diet.

Total weight gain as an index of availability of an amino acid is not the best criterion when one is assaying foods of varying fiber content (Table 5.). When whole wheat was assayed, the great bulk of the gastrointestinal contents due to high-fiber content of whole wheat was reflected as weight gain and thus served to increase the apparent availability of the amino acid under study. This table reveals that the availability of lysine from wheat, flour, bread, and gluten is 78, 80, 83, and 80 percent, respectively. Similar or greater availabilities were found for the remaining seven essential amino acids. Steele et al. (7) using human subjects found that the methionine of flour was 100 percent available to humans. Experiments in our laboratory indicated an availability of 94 percent to rats.

Table 5. Availability values for lysine in wheat, flour, bread and gluten, expressed as percentage[1/]

Performance index[2/]	Wheat	Flour	Bread	Gluten
Weight gain	87	85	84	83
Empty weight gain	74	83	83	83
Carcass nitrogen gain	78	80	83	80

1/ Percent availability = $\frac{\text{lysine found by rat assay}}{\text{lysine found by microbiological assay}} \times 100.$

2/ Method of calculation: gain versus grams available lysine consumed.

The amino acid diet used in determining the availability of amino acids of wheat gave surprisingly good rat growth as compared to the growth reported by other investigators using amino acid diets. The pattern of amino acids used followed that of wheat gluten supplemented with small quantities of lysine, histidine, methionine, threonine, and tryptophan. Some work has been done to elucidate the unusual growth-promoting effect of this particular amino acid diet, which, when fed after a four-day adaptation period, produces growth in excess of 40 g. per week, and without this adaptation period, growth is around 35 g. per week. The unique aspect of this diet, not shared by the diets of other investigators, was the fact that it contained the entire spectrum of nonessential amino acids. It was found (8), however, that any one of these amino acids or combinations could be eliminated from the diet without adversely effecting rat growth as long as the level of glutamic acid was not reduced. Glutamic acid appears to have some specific effect on rat growth over and beyond that of other sources of nonessential nitrogen.

Table 6. Weight gain, food efficiency and carcass composition after three weeks feeding of an amino acid diet with graded levels of glutamic acid

Level of glutamic acid	Weight gain	G. gain/ g. food	Carcass	
			Nitrogen	Fat
%	g./week		%	%
0.00	14.9	0.43	2.805	7.12
1.42	19.9	0.42	2.686	8.33
2.83	23.5	0.44	2.763	8.44
4.25	28.9	0.46	2.834	9.24
5.66	34.9	0.50	2.861	8.58
7.08	34.8	0.48	2.919	8.58
8.50	35.5	0.49	2.864	9.70
10.97	29.8	0.46	2.908	10.00

Table 6 shows the effect of varying levels of glutamic acid in the diet. The diets were kept isonitrogenous by adding more of the remaining nonessential amino acids when the glutamic acid level was lowered, and by substituting glutamic acid for the remaining nonessential amino acids when the glutamic acid level was increased. For each increment between 0 and 5.66 percent glutamic acid there was an increase in rate of growth with a plateau between 5.66 and 8.5 percent. Growth rate fell off at the highest level where glutamic acid entirely replaced the remaining nonessential amino acids. The mechanism of this effect of glutamic acid on growth is not known and work is in progress to explain this beneficial effect of glutamic acid on rat growth.

Several investigators (9, 10, and 11) have studied the amino acid composition of pure wheat varieties hoping to find some with higher lysine content than is true of wheat in general. Each investigation has revealed that the proteins of low-protein wheat contain a higher proportion of lysine than the proteins of high-protein wheat. Unfortunately, however, this offers nothing of nutritional significance, because if one performs the necessary mathematics, he finds that the low-protein wheat furnishes less total lysine than the high-protein wheat.

Lawrence *et al.* (11) reported lysine contents of a number of varieties of spring and winter wheats. Figure 2 presents the data obtained on spring wheats. It

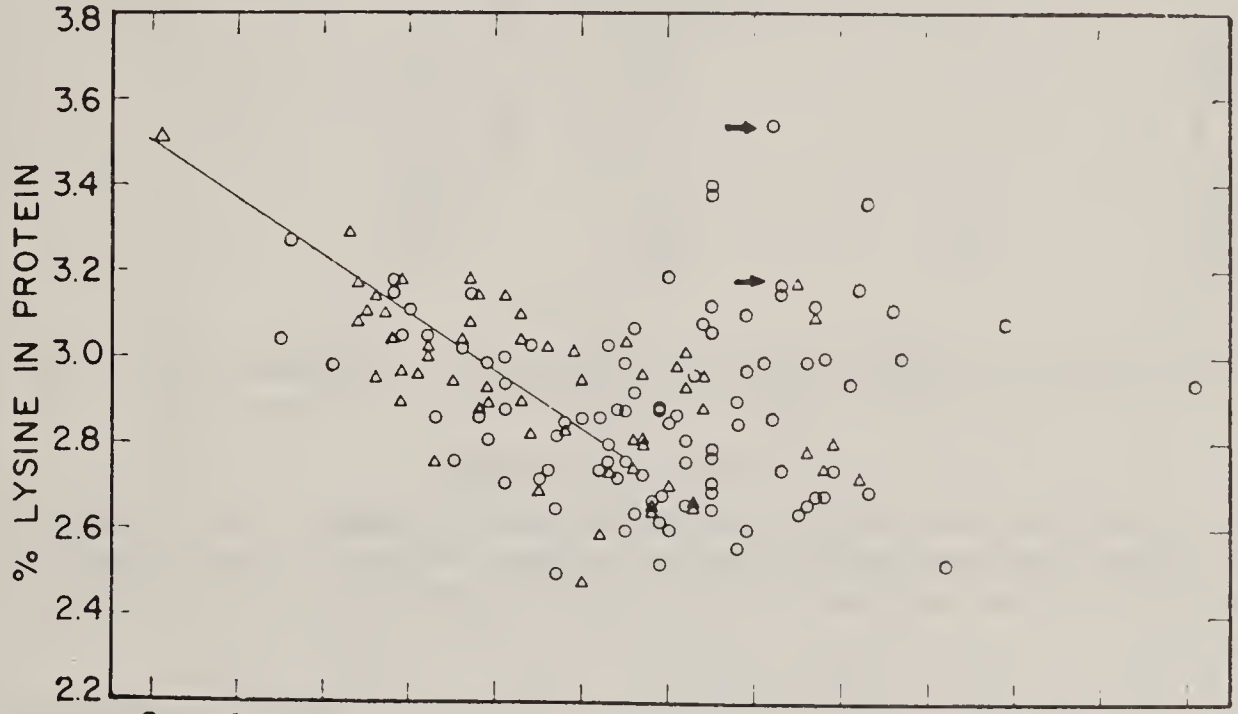

Figure 2. Lysine content of 155 varieties of spring wheat. Each point represents the mean analysis for one sample of one variety, except where arrows point to results of analyses of two samples of the Mexican variety, CI No. 5286. Circle, red spring wheats; triangle, white spring wheats.

is to be noted that the average lysine content of the wheat protein decreases with increasing protein content of the wheat; however, the amount of lysine contributed by 100 g. of the low-protein wheat is only 0.28 g. while the amount of lysine contributed by 100 g. of the higher-protein wheat is 0.37 g.

Unfortunately, the high lysine value of the Mexican variety CI No. 5286 has not held up on subsequent sampling (12). Figure 3 shows the relationship between the percent lysine in wheat protein to percent protein in wheat for winter-wheat varieties. Here again, a variety of high-protein wheat, Wilhelmina, showed a relatively high lysine content which has not been found in subsequent samples.

Within the past few years, additional information has been obtained concerning the vitamin content of wheat and wheat foods. Table 7 shows the vitamin content of wheat, flour, and bread (13). Thiamine, niacin, biotin, folic acid, and vitamin B_6 must share a similar distribution in the wheat kernel, since each undergoes a reduction of approximately 80 percent in the milling of wheat into white flour. Inositol and p-aminobenzoic acid must be even more concentrated in the fractions lost during the production of white flour. Pantothenic acid suffers a lesser milling loss while choline appears to be rather evenly distributed throughout the wheat kernel. Undoubtedly, most of the inositol in wheat is combined with phosphate in the form of phytic acid which is

hydrolyzed in our method of analysis. The substantial increases in thiamine, riboflavin, and niacin of bread are due to the enrichment factors added in manufacture.

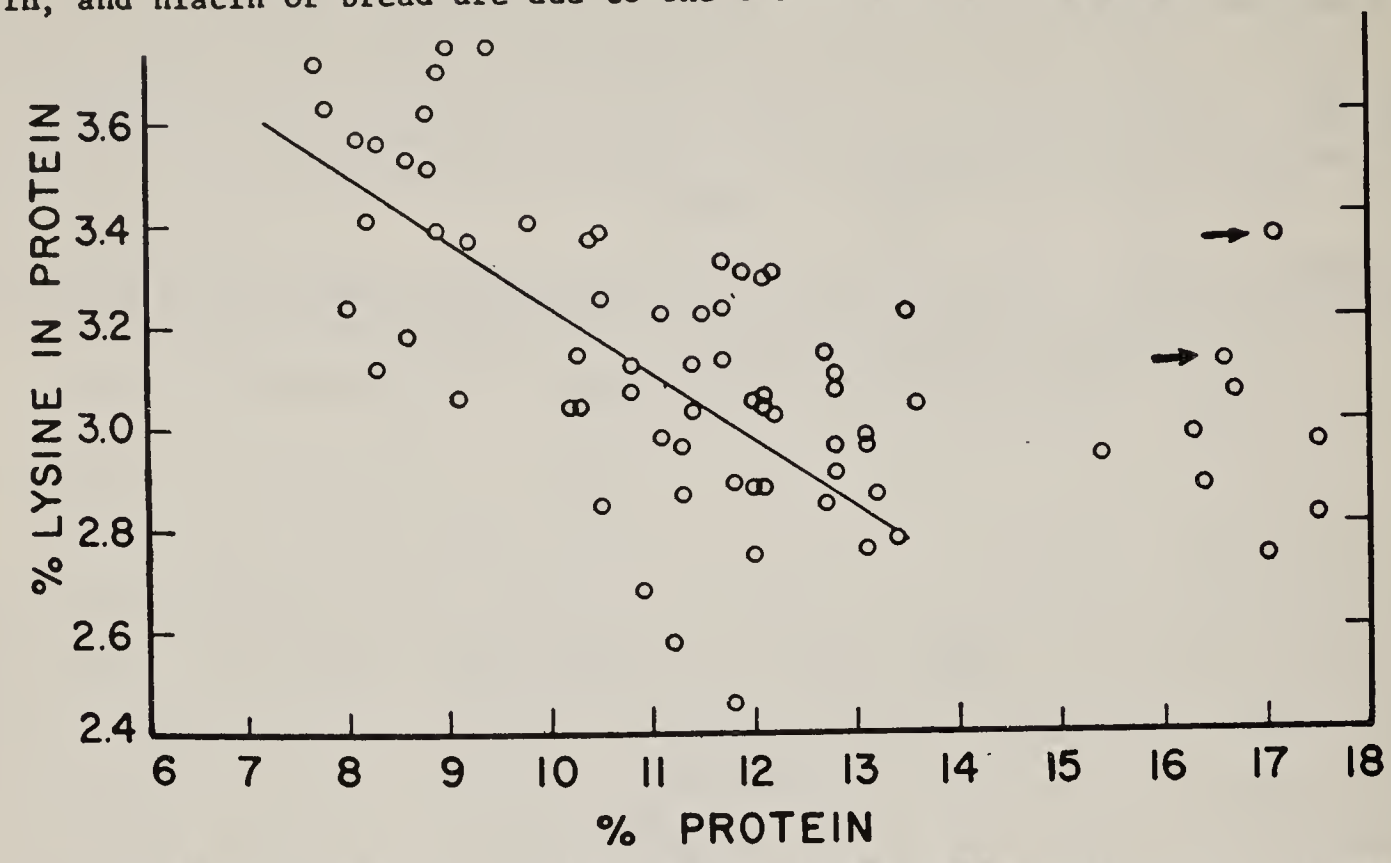

Figure 3. Lysine content of 75 varieties of winter wheat. Each point represents the mean analysis for one sample of one variety, except where arrows point to results of analyses of two samples of the variety Wilhelmina. CI No. 4193.

Table 7. Vitamin content of wheat, flour, and bread (mg./100 g. dry wt.)

	Wheat	Flour	Bread
Thiamine	0.44	0.09	0.36
Riboflavin	0.15	0.04	0.30
Niacin	6.3	1.2	4.0
Biotin	0.014	0.002	0.003
Pantothenic acid	1.1	0.5	0.6
Folic acid	0.05	0.01	0.05
Choline	211.	211.	199.
Inositol	341.	38.	44.
p -Aminobenzoic acid	0.4	0.04	0.08
Vitamin B_6	0.47	0.08	0.065

Table 8. I. Vitamin content of products commercially milled from a single wheat blend (mg./100 g. 14% moisture basis)

	Wheat	Bran	Shorts	Red Dog
Thiamine	0.393	0.629	1.34	2.80
Riboflavin	.107	.334	.347	.322
Niacin	5.45	26.60	16.00	8.01
Pantothenic acid	1.09	3.91	2.66	1.82
Folic acid	.050	.088	.135	.120
Biotin	.0114	.0440	.0350	.0250
p-Aminobenzoic acid	.383	1.48	1.26	.781
Choline	163.	154.	176.	174.
Inositol	315.	1340.	1080.	808.

Table 8 shows the vitamin content of wheat, bran, shorts, and red dog. The high concentration of vitamin in the shorts and red dog fraction supports the hypothesis made previously that these mill products could be made into an excellent food for very young humans. The concentration of inositol in the bran is expected because it is well known that phytic acid is concentrated in this fraction.

Table 9. II. Vitamin content of products commercially milled from a single wheat blend (mg./100 g. 14% moisture basis)

	Germ	Low-grade flour	First-clear flour	Patent flour
Thiamine	1.35	1.08	.245	.076
Riboflavin	.487	.124	.048	.032
Niacin	4.53	3.86	2.09	1.01
Pantothentic acid	1.04	.915	.675	.483
Folic acid	.205	.042	.018	.011
Biotin	.0174	.0108	.0042	.0014
p-Aminobenzoic acid	.370	.295	.126	.033
Choline	265.	148.	151.	161.
Inositol	852.	341.	113.	33.

Table 9 gives the vitamin content of germ, low-grade, first-clear, and patent flours (14). Unlike amino acids, the vitamin content of flour is markedly influenced by the degree of refinement; the more highly refined flours show the greater loss. This is made apparent by the differences in vitamin values for patent and first-clear flours. Although it is generally considered that the loss of germ in the milling of wheat to white flour greatly decreases flour's nutritional value, the single factor which accounts for the greatest loss of vitamins is the removal of the bran. The bran fraction contained the following percentages of the individual vitamins found in the whole wheat: pantothenic acid, 53.2; riboflavin, 39.6; thiamine, 22.7; vitamin B_6, 51.2; folic acid, 26.3; niacin, 72.5; biotin, 57.4; inositol, 63.3; and p-aminobenzoic acid, 57.5.

Table 10. Effect of dietary protein on serum cholesterol concentration in the rat

Protein	Level of protein in the diet	Average daily food intake per rat	Average weight gain for 3 weeks	Serum cholesterol
	%	g.	g.	mg. %
I. Casein	6.	3.5	-2 ± 1 [1/]	853 ± 79 [1/]
	40.	8.9	93 ± 1	431 ± 39
	69.5	7.8	85 ± 2	561 ± 64
II. Wheat gluten	10.	3.4	-2 ± 2	486 ± 38
	30.	6.7	38 ± 2	250 ± 31
	40.	7.6	56 ± 6	210 ± 8
	68.5	8.8	101 ± 5	167 ± 10
Wheat gluten supplemented with 1% lysine	30.	10.6	102 ± 7	260 ± 11

1/ Standard error of the mean.

One other thing I would like to mention as something which represents relatively recent research with regard to wheat products is the work published by Nath et al. (15), concerning the effect of dietary protein on serum cholesterol concentration in the rat. Rats were fed cholesterolgenic diets containing varying levels of casein and wheat gluten. Table 10 shows the response to these diets. As the casein level in the diet was increased from 6 to 69.5 percent, serum cholesterol decreased from its high value of 853 to a low of 431 and again went upward to 561 at the highest protein level. When wheat gluten was the protein source in the diet, the serum cholesterol was lowered initially to 486 and decreased with each increment of wheat gluten up to a protein level of 68.5 percent where the serum cholesterol was found to be 167. This effect (16, 17) has since been demonstrated to be due to the lipids associated with the protein of wheat gluten. Since wheat gluten is made from wheat flour, these lipids are present in the wheaten product whether it is made from the whole grain or from white flour. It may not be mere coincidence that the epidemiological evidence used to support the thesis that high fat intake results in high blood cholesterol (and also a high incidence of atherosclerosis and coronary heart disease), also supports the hypothesis that high cereal intake protects against high blood cholesterol, atherosclerosis, and coronary heart disease.

I show this table for another reason: the literature contains many examples of the improvement in growth of experimental animals with increasing quantities of protein in the diet and then decreasing growth rate as a certain optimum level is exceeded. This table shows this to be true when casein is the protein source, but it shows no such effect of excess protein when wheat gluten is the protein source. This may be related to the work discussed previously which demonstrated the beneficial effect of glutamic acid on rat growth.

To summarize: Analysis of wheat and products made from it indicate that wheat, although not an outstandingly good source of a single nutrient, is a good source of most of them. Wheat also is a food which cannot be used without some processing. In processing it can be made to carry any nutrient concentration deemed desirable. Milling produces a white flour having a lower concentration of many of the essential nutrients, the extent of which depends upon the degree of refinement. Milling permits the production of fractions having especially high nutritional quality. Thus milling could be used as a means of producing custom-made cereal foods, whose high concentration of amino acids and vitamins makes them especially suited for infants. At the same time, white flour would be produced which, if consumed as a major source of calories, would furnish sufficient amino acids for older children and adults and, if not overly refined, could furnish many of the vitamin requirements as well.

Discussion. In discussion of the tests used, it was pointed out that the microbiological amino acid assay was carried out on the hydrolyzed cereal product and the feeding tests on an unhydrolyzed product. Availability of lysine was determined by the relation of growth on the cereal product to that on a diet containing known amounts of added free lysine. Lysine available from bread was 83 percent of the lysine determined microbiologically. Work is now being conducted to correlate chick and rat assay with chemical methods based on the ϵ-amino group of lysine.

The ability of certain African groups to be in apparent good health on diets sub-standard in protein brought out questions of whether the safety factors normally used may be too high, and whether the relation of rat response to response of all groups of humans may be oversimplified. It was decided that both ideas probably have substance, particularly since humans grow much more slowly.

BIBLIOGRAPHY

1. Hepburn, F. N., Lewis, E. W., and Elvehjem, C. A. The amino acid content of wheat, flour, and bread. Cereal Chem. 34: 312-322 (1957).

2. McDermott, E. E., and Pace, J. The content of amino acids in white flour and bread. Brit. J. Nutr. 11: 446-452 (1957).

3. McDermott, E. E., and Pace, J. Comparison of the amino-acid composition of the protein in flour and endosperm from different types of wheat with particular reference to variation in lysine content. J. Sci. Food Agr. 11: 109-115 (1960).

4. Nunnikhoven, R., and Bigwood, E. J. Variation de la composition en acides aminés de la farine de froment en function du pourcentage de son extraction du grain de blé. Nutritio et Dieta 1: 177-191 (1959).

5. Hepburn, F. N., Calhoun, W. K., and Bradley, W. B. The distribution of the amino acids of wheat in commercial mill products. Cereal Chem. 37: 749-755 (1960).

6. Calhoun, W. K., Hepburn, F. N., and Bradley, W. B. The availability of lysine in wheat, flour, bread, and gluten. J. Nutr. 70: 337-347 (1960).

7. Steele, D. S., Miller, L. T., Baumann, and Reynolds, M. S. Nitrogen balances of human subjects fed free of bound methionine (wheat flour). Proc. Fed. Amer. Soc. Expt. Biol. 17: 494 (1958).

8. Hepburn, F. N., Calhoun, W. K., and Bradley, W. B. A growth response of rats to glutamic acid when fed an amino acid diet. J. Nutr. 72: 163-168 (1960).

9. Pence, J. W., Mecham, D. K., Elder, A. H., Lewis, J. C., Snell, Neva, and Olcott, H. S. Characterization of wheat gluten. II. Amino acid composition. Cereal Chem. 27: 335-341 (1950).

10. Bendicenti, A., Bogliolo, M., Montenero, P., and Spadoni, M. A. Contenuto in amino-acidi di alcune varieta di frumenti italiani a diversa percentuale in azoto. Quaderni della Nutrizione 17: 149-158 (1957).

11. Lawrence, J. M., Day, K. M., Huey, E., and Lee, B. Lysine content of wheat varieties, species, and related genera. Cereal Chem. 35: 169-178 (1958).

12. Lawrence, J. M., personal communication.

13. Calhoun, W. K., Bechtel, W. G., and Bradley, W. B. The vitamin content of wheat, flour, and bread. Cereal Chem. 35: 350-359 (1958).

14. Calhoun, W. K., Hepburn, F. N., and Bradley, W. B. The distribution of the vitamins of wheat in commercial mill products. Cereal Chem. 37: 755-761 (1960).

15. Nath, N., Harper, A. E., and Elvehjem, C. A. Dietary protein and serum cholesterol. Arch. Biochem. and Biophys. 77: 234-236 (1958).

16. Nath, N., Harper, A. E., and Elvehjem, C. A. Diet and cholesteremia III. Effect of dietary proteins with particular reference to the lipids of wheat gluten. Canad. J. Biochem. Physiol. 37: 1375 (1959).

17. Nath, N., Seidel, J. C., and Harper, A. E. Diet and cholesterolemia VI. Comparative effects of wheat gluten lipids and some other lipids in presence of adequate and inadequate dietary protein. J. Nutr. 74: 389-396 (1961).

NUTRITIONAL VALUES OF BULGUR

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My introduction to parboiled wheat, called bulgur, burghul or a similar name, was on my first trip to San Francisco. A couple of years ago when the Pan Rim Food Conference was held in Honolulu, parboiled wheat again came to my attention. This time, W. L. Haley (1960) talked on "Bulgur Wheat and Its Export Potential for the Far East." I believe this was still an unfamiliar product to most of his audience. Some one brought bread, similar to cracked wheat bread but containing bulgur for us to sample.

I talked with James Pence, of this Laboratory here about the nature of the protein in parboiled wheat. I was interested, as practically all of our nutrition work in the Department of Foods and Nutrition at Purdue at that time was concerned with the nutritive value of cereal proteins. We were concerned with lysine and the effect of lysine supplementation of cereal proteins, especially those of flour, on their nutritional value to both man and albino rats.

In discussing the foods of the Near East, Adolph (1954) indicated that 30 percent of the land area in crops is given over to wheat. He included in the Near East Syria, Lebanon, Jordan, Egypt, Iraq, and Saudi Arabia. He stated that Iran is similar in many respects. Although according to this author, wheat, the principal cereal and the mainstay of the diet, is eaten mainly as whole wheat bread, parboiled wheat is used almost everywhere throughout the Near East area. It does not replace bread but is an adjunct to it. It is used much as rice is used in cooked dishes. Adolph stated that "Burghul (parboiled wheat) ... is essentially a means of keeping wheat over a prolonged period." In the Near East, bulgur is usually prepared by the individual households, not in factories, and according to Shammas and Adolph (1954) it can be kept without difficulty until the next harvest, or if necessary for several years. These authors reported that whereas rice is desired for its white color and other qualities, parboiled wheat is regarded by the rural people as superior to rice as a source of energy and vigor. As much as one-fourth of the wheat crop may be converted to parboiled wheat.

The following steps are involved in the preparation of bulgur in the Near East (Saracoglu 1953): (1) washing to remove foreign materials and impurities, (2) boiling to gelatinize the starch, (3) air drying: most effective in the sun, (4) beating in the mortar to separate the hulls, (5) fanning to remove the hulls, (6) crushing in mills, and (7) rough sieving to remove fine parts. The long periods of dry weather and the flat tops on the houses provide excellent conditions for the drying process.

We might briefly examine the claim of keeping quality. The hard, brittle nature of the finished product undoubtedly discourages insects; the low moisture content retards the growth of molds and boiling has sterilized the grain and no doubt destroyed the enzymes naturally present. Rancidity develops in bulgur stored at high temperatures for a period of months (Neufeld et al., 1957). However, this apparently does not reach a point of being objectionable as bulgur is prepared and consumed by the people of the Near East. In fact, a certain degree of rancidity may be acceptable or even desirable, as it seems to be in certain other foods.

From our point of view two important considerations enter into the use of parboiled wheat not only in the Near East but in other parts of the world and especially in those areas where there is a deficit of food. The first is acceptance. There seems to be no question of acceptance on the part of people who have used bulgur for

thousands of years, but we are reluctant to try the unfamiliar. Limited reports indicate those who have tried it like it, but I found no well-documented evidence of wide acceptance. The second consideration, nutritive value, is the one with which we are primarily concerned at this time. Adolph (1954) pointed out, in discussing the use of wheat in the Near East, that it is advisable that the habit of using whole cereals should not be lost and that even more extended use of these products is to be recommended.

Neufeld et al. (1957) stated that "although available data are limited, it appears to have been widely accepted that bulgur is a product offering nutritional advantages because of the extent to which thiamine, niacin, and perhaps other nutritionally valuable constituents of whole wheat are retained in the product." One assumes the nutritional advantages are compared with white flour.

Perhaps before considering reports on the nutritive value of bulgur, the distribution of nutrients in the different parts of the wheat kernel should be reviewed. Let us consider the vitamins first. Jackson and co-workers (1943) examined the various streams of flour for certain of the B-vitamins. They concluded that the thiamine is largely concentrated in the scutellum portion of the wheat germ. They found that 93.2 percent of the wheat kernel other than the embryo and the scutellum contained only 30 percent of the thiamine. Riboflavin appeared to be fairly evenly distributed throughout the wheat kernel. Hence, treatment, including the milling process, is not likely to increase materially the concentration of riboflavin in any part of the grain or the mill stream. Niacin, on the other hand, is concentrated in the branny layer. Nearly one-half of the total niacin appeared in the bran stream.

Numerous studies have dealt with the effect of processing on the vitamin content of bulgur. Saracoglu (1953) studied the thiamine content of 28 samples of wheat and of bulgur made from them. He found a range from 0.31 to 0.50 mg. thiamine/100 g. of wheat and a mean of 0.39 mg./100 g. Although this amounted to an average loss of 27.3 percent the loss varied from 8.9 to 42.4 percent for the different samples. This worker attributed the greatest loss to the boiling step - 22.6 percent. This he stated was due to solution and destruction by heat. Haley and Pence (1960) reported the thiamine content of bulgur as 30.8 percent less than that of the wheat but they found the greatest loss in the washing process. The close agreement in percentage of thiamine lost is interesting. The difference in the processing step where the major loss occurs may well be due to the processing methods used. Haley and Pence stated that "Washing is the only stage in which excess water is used and discarded." Saracoglu concluded that the loss of thiamine was influenced by variety of wheat, relative proportions of wheat and water, pH, and duration and manner of boiling. He further stated that to obtain bulgur high in thiamine: start with wheat of high thiamine content; shorten the boiling period; and omit sieving.

The latter recommendation was based on his findings, with 4 samples of wheat, that the fine part of the crushed bulgur had a thiamine content 93.7 percent that of the original wheat, whereas the coarse had only 71.3 percent. Haley and Pence did not report this difference. Both articles report no serious loss in thiamine content due to removal of bran after parboiling and drying.

Sabry and Tannous (1961) prepared bulgur using 5 parboiling periods ranging from 0.5 hour to 3 hours. They found that thiamine content decreased as boiling time increased, changing from 0.58 mg./100 g. of unheated wheat to 0.21 mg./100 g. when boiled for 3 hours. Riboflavin losses due to boiling were somewhat less, changing from 0.15 mg./100 g. for unheated wheat to 0.10 mg./100 g. after boiling 3 hours. However, these workers compared forced-draft oven drying with sun drying and found the loss to be 20 percent and 76 percent, respectively, when the wheat had been boiled for 2 hours. These workers reported 4.1 mg. niacin/100 g. of unheated bulgur and 10.1 mg. of unheated bran. After boiling for one hour they reported the niacin content for

100 grams to be 5.1 mg. for the bulgur and 4.7 mg. for the bran. The niacin of the bulgur tended to increase with increased time of boiling although the greatest increase was in the first hour. The niacin in the bran decreased with time of boiling.

They (Sabry and Tannous) concluded that changes appear to be due to direct heat destruction and the redistribution of the vitamins from the outer layers to the inner layers of the wheat. Since the bran is rich in niacin and the germ is the part considered richest in thiamine and riboflavin, the vitamin redistribution (as a result of parboiling) has a more pronounced effect on the niacin content of the parboiled wheat than on the thiamine and riboflavin.

Haley and Pence (1960) and Shammas and Adolph (1954) published tables comparing the composition of wheat and bulgur. Although the protein content of the original wheat differs, the comparisons are remarkably similar except for the riboflavin. That reported by Shammas and Adolph leads to the conclusion that they are reporting on sun-dried bulgur.

Turning now to the protein of wheat, we find that it has been extensively studied with both man and animals as subjects. Lysine is recognized as the first limiting amino acid in both whole wheat and white flour proteins. However, Sure (1957) found that when proteins of milled wheat were fed to albino rats at an 8 percent level, optimum gain in body weight and protein efficiency were secured by supplementation with 0.4 percent L-lysine, 0.2 percent DL threonine, 0.4 percent DL methionine and vitamin B_{12}. Harris and Burress (1959) showed that when fed at 15 percent level, lysine-fortified wheat protein was nutritionally equal to egg albumin as measured by body weight increase and protein efficiency, but inferior in its ability to promote the synthesis of body protein.

Examination of the data on the protein of wheat and flour may help to explain results obtained with feeding experiments. Pence et al. (1950) reported that the gluten fraction of widely different flours had almost identical amino acid compositions. Hepburn et al. (1957) suggested that not only gluten but the entire protein may follow a consistent pattern. These latter workers found a 24 percent loss of lysine in converting wheat to patent flour (71.8 to 74.4 percent yield) and a 7 percent loss of threonine. Later Hepburn and co-workers (1960) reported less lysine, glycine, arginine, alanine, and aspartic acid in the flour fractions and more in the offals than in the wheat proteins. Conversely more proline, glutamic acid, and phenylalanine were found in the flour proteins and less in the offals than in the wheat. The remaining amino acids were less affected by milling. Horn et al. (1958) showed the bran and shorts to have a considerable higher concentration of arginine, lysine, and threonine than flour of 71.5 percent extraction or the whole wheat. When comparison was made with flour of 84.9 percent extraction a marked difference was not found for either lysine or threonine.

The effect of parboiling on these amino acids was not found in the literature. It is well recognized that under certain conditions the availability of lysine in bread, biscuits and other foods is decreased by baking (Rosenberg and Rohdenburg, 1951, Clark, 1959). Preliminary work in our laboratories with bulgur and whole wheat shows them to be essentially the same in lysine content.

Shammas and Adolph (1954) fed whole wheat and parboiled wheat as the only food to weanling rats and obtained almost identical growth rates and protein efficiency ratios. These workers concluded that the parboiling process does not significantly alter the nutritive value of wheat proteins.

From our laboratories at Purdue University, we have work by Yang and his students in which certain characteristics of wheat, bulgur, and 70 percent extraction white flour were compared. A slight difference was found in the nitrogen content of

the parboiled wheat and whole wheat. Shammas and Adolph (1954) reported a similar difference.

The ash was found to be only slightly less for the parboiled wheat than the whole wheat. This too, agrees with the work of Shammas and Adolph. Haley and Pence (1960) pointed out that a fairly large part of the bran nutrients is retained in the finished bulgur. They estimated that two-thirds of the phosphorus and more than 80 percent of the iron of the wheat was in the bulgur. They assumed that the substantially higher amount of calcium in the bulgur might be due to the inward transfer of nutrients during parboiling and could be influenced by the mineral composition of the water used for parboiling. Shammas and Adolph did not find the decrease in fat reported by Haley and Pence and found in Yang's investigation.

A uniform basal diet was used in the study of wheat proteins from three sources, namely whole wheat, parboiled wheat, and white flour. Weanling rats were given the experimental diet ad libitum for 4 weeks. The wheat products and other sources of protein being studied were added at the expense of the sucrose. The data were subjected to the analysis of variance (Snedecor 1956) and Duncan's multiple range test using 1 percent as the significant level (Duncan, 1955).

Five experiments will be reported. In this first one the animals were fed diets containing 7 percent protein supplied by parboiled wheat, whole wheat or white flour. The weight gain in a 4-week period was 38.7, 34.3 and 14.0 g. respectively. These differences are reflected in the protein efficiency ratio. The protein efficiency ratio and biological value of the diet containing parboiled wheat were not significantly different from the values of the comparable diet containing whole wheat, but were significantly greater than those for white flour.

The 7 percent protein level, when derived from wheat, is low for the growing rat; therefore 3 percent casein protein was added. Protein efficiency ratio for diets containing parboiled wheat and whole wheat were the same. Weight gains were 144.4 and 143.6 grams,respectively. On the diet containing white flour the gain was 113.0 g. The mean food intake, weight gain and protein efficiency ratio for the rats fed the parboiled wheat and the whole wheat diets were significantly greater than for those consuming the white flour diet.

The effect of supplementing a 7 percent parboiled wheat protein diet with amino acids was studied. To the basal diet, 0.2 percent L-lysine, 0.2% DL-methionine and 0.1 percent L-threonine were added either alone or in combination. The addition of lysine alone resulted in a significant decrease in the protein efficiency ratio. The addition of methionine and threonine alone or together and the addition of lysine plus methionine had no significant effect. The addition of lysine plus threonine resulted in a marked increase in protein efficiency ratio and biological value. The combination of lysine, threonine and methionine gave a slightly higher protein efficiency ratio and a significantly higher biological value than did lysine and threonine.

A similar supplementation was made of a whole wheat protein diet. Again the protein efficiency ratio when the wheat protein was supplemented with lysine and threonine was significantly higher than when supplemented with lysine, threonine, methionine, lysine and methionine, or threonine and methionine but not as high as that of the diet in which lysine, threonine, and methionine were used as supplements. The biological value of the diet containing lysine and threonine and that of the one containing lysine, threonine, and methionine did not differ significantly and were higher than all other diets.

A third diet was used in which white flour was the source of protein. The protein efficiency ratio and the biological value are low as compared with protein from parboiled or whole wheat. The protein efficiency ratios of diets to which lysine

or lysine and methionine were added did not differ significantly but were greater than those of the unsupplemented diet - or of the diets to which methionine, threonine or methionine and threonine were added. The protein efficiency ratios of the diets to which lysine and threonine or lysine, threonine, and methionine were added were similar and higher than that of other diets.

Yang reported the proteins of the whole wheat, parboiled wheat, and white flour contained 2.5, 2.5 and 2.0 percent lysine respectively as determined by microbiological assay using Leuconostoc mesenteroides P-60 and the medium developed by Steele et al.(1949).

The foregoing data would seem to indicate that lysine is the first limiting amino acid in white flour and threonine the second, whereas parboiled and whole wheat protein when fed at the 7 percent level are apparently deficient in both lysine and threonine. The low level of protein intake is a possible explanation of the failure of the rats to respond to lysine supplementation of the parboiled and whole wheat proteins - which were already approximately 25 percent higher in lysine than was the white flour protein. Hutchinson and co-workers (1959) pointed out, in connection with their work with the protein of white bread, that at a 7 or 8 percent protein intake, the threonine limitation showed up at lower levels.

A final experiment was based on feeding a combination of parboiled wheat and chicken protein. Starting with 8 percent parboiled-wheat protein, this was replaced 1 or 2 percent at a time by chicken protein. There was a decided increase in weight gain, protein efficiency ratio, and biological value with an increase in chicken protein up to 4 percent. Six percent chicken protein resulted in the same weight gain as 4 percent, a slightly higher protein efficiency ratio but a slightly lower biological value.

Thus we might assume that the peoples of the Middle East who combine bulgur and meat to make a substantial part of a meal are combining proteins from two sources to give a highly nutritive dish.

As a result of this work Yang concluded that the nutritional value of the protein of parboiled wheat, when fed to young rats as the sole source of protein or in combination with casein, or supplemented with lysine, methionine or threonine singly or in combination, was similar to that of whole wheat, but as was expected different from that of white flour protein. When animals were fed a diet containing 8 percent protein from parboiled wheat or the same diet in which 1, 2, 3, or 4 percent of the protein was replaced by an equal percentage of protein from chicken meat, the nutritional values of the diets increased as the level of chicken protein increased.

Work of others has shown the similarity in vitamin and ash content of whole wheat and bulgur. Keeping quality and acceptability are factors in favor of bulgur as compared with whole wheat. To this might be added the comparatively short cooking required and the ease of preparation of processed bulgur for the table.

Discussion. Questions regarding processing effects on bulgur properties developed the information that sundrying did not destroy much of the thiamine if the drying time was short, and that bulgur could be kept longer than wheat because processing destroyed enzymes and provided a hard insect-resistant surface. Rancidification was not prevented, however.

REFERENCES

Adolph, W. H. 1954. Nutrition in the Near East. J. Amer. Dietet. Assoc. 30:753-756.

Clark, H. E., Howe, J. M., Mertz, E. T., and Reitz, L. L. 1959. Lysine in baking powder biscuits. J. Amer. Dietet. Assoc. 35:469-471.

Duncan, D. B. 1955. Multiple range and multiple F. test. Biometrics 11:1.

Haley, W. L. 1960. Bulgur wheat and its export potential for the Far East. Technical Papers of the First Pacific Rim Food Conference.

Haley, W. L., and Pence, J. W. 1960. Bulgur, an ancient wheat food. Cereal Sci. Today 5:203-208.

Harris, R. S., and Burress, D. A. 1959. Effect of level of protein feeding upon nutritional value of lysine-fortified bread flour. J. Nutr. 67:549-567.

Hepburn, F. N., Lewis, E. W., Jr., and Elvehjem, C. A. 1957. The amino acid content of wheat, flour and bread. Cereal Chem. 34:312-322.

Hepburn, F. N., Calhoun, W. K., and Bradley, W. B. 1960. The distribution of the amino acids of wheat in commercial mill products. Cereal Chem. 37:749-755.

Horn, M. J., Fifield, C. C., Blum, A. E., and Warren, H. W. 1958. The distribution of amino acids in wheat and certain wheat products. Cereal Chem. 35:411-421.

Hutchinson, J. B., Moran, T., and Pace, J. 1959. The nutritive value of bread protein as influenced by the level of protein intake, the level of supplementation with L-lysine and L-threonine, and the addition of egg and milk proteins. Brit. J. Nutr. 13:151-163.

Jackson, S. H., Doherty, A., and Malone, V. 1943. The recovery of the B vitamins in the milling of wheat. Cereal Chem. 20:551-559.

Neufeld, C. H. H., Weinstein, N. E., and Mecham, D. K. 1957. Studies on the preparation and keeping quality of bulgur. Cereal Chem. 34:360-370.

Pence, J. W., Mecham, D. K., Elder, A. H., Lewis, J. C., Snell, N. S., and Olcott, H. S. 1950. Characterization of wheat gluten. II. Amino acid composition. Cereal Chem. 27:335-341.

Rosenberg, H. R., and Rohdenburg, E. L. 1951. The fortification of bread with lysine. I. The loss of lysine during baking. J. Nutr. 45:593-598.

Sabry, Z. I., and Tannous, R. I. 1961. Effect of parboiling on the thiamine, riboflavin and niacin contents of wheat. Cereal Chem. 38:536-539.

Saracoglu, S. 1953. The thiamine content of Turkish wheats and corresponding bulgurs. Cereal Chem. 30:323-327.

Shammas, E., and Adolph, W. H. 1954. Nutritive value of parboiled wheat used in the Near East. J. Amer. Dietet. Assoc. 30:982-983.

Snedecor, G. W. 1956. Statistical methods. 5th ed., Iowa State College Press, Ames, Iowa, Chap. 11.

Steele, B. F., Sauberlich, H. E., Reynolds, M. S., and Baumann, C. A. 1949. Media for Leuconostoc mesenteroides P 60 and Leuconostoc citrovorum 8081. J. Biol. Chem. 177:533-544.

Sure, B. 1957. Influence of addition of certain amino acids and vitamin B_{12} to proteins in enriched milled wheat flour on growth, protein efficiency and liver fat deposition. J. Agr. Food Chem. 5:373-375.

Five girls who lived for a year on experimental diets.
(See following report by Elsie M. Widdowson.)

THE VALUE OF BREAD FOR THE NOURISHMENT OF CHILDREN

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I have been invited here to tell you the story of some investigations we made in Germany just after the war (Widdowson and McCance, 1954). A team of us went to Germany in 1946 to study the physiological effects of under-nutrition on the civilian population. Food was short and most people were undernourished, though nobody was starving. The cities were in ruins, the result of our bombing raids, and altogether things were not too cheerful. The winter of 1946 - 47 was the worst time, for the weather was very severe and the rations were not being honoured. Bread queues began to form at 6 o'clock in the morning.

In December, 1946, I came home to England on leave, and while I was there a meeting was called by the Medical Research Council to discuss the extraction rate of the flour that should be used for bread making in post-war Britain. During the course of this meeting it became clear that we had no real evidence as to whether brown bread or white was the better food for man, and the suggestion was made that we should try to make use of the opportunities of being in Germany to make an investigation into the nutritive value of breads made from flours of different extraction rates and enriched with various amounts of minerals and vitamins. Up to this time we had been working almost entirely amongst adults, for it was adults who developed hunger oedema and came to our clinics. Children were obviously better subjects than adults for a study such as we had in mind, and I went back to Germany to find a children's home where we might make such an investigation.

The municipal orphanage at Duisburg was selected. Duisburg is about 30 miles from Wuppertal, where our unit had its headquarters and laboratories. The town had been badly bombed but the orphanage was still standing. It was rather a dreary building, housing about 180 children and 30 to 40 old women. Very few of the children were orphans in the strict sense of the word, for most had one parent alive. Many of them were illegitimate, or their legitimate parents were in prison for stealing ration books or dealing on the black market. When we first saw the children they seemed very lively and energetic, but small. Many of them looked thin, and most of them had pot bellies.

The orphanage was run by a married couple who believed in very strict discipline. The children were not allowed to speak at meal times and were sent out of the room or into the corner if they did. When we first suggested that the children should be provided with unlimited amounts of bread, the couple in charge were very thankful, for they knew that the children were not getting enough to eat, but to the very end they were worried about the moral effects of allowing the children to eat as much food as they wanted. In spite of their misgivings, however, they cooperated with us and supported us in every possible way all the time we were there.

The normal arrangement at the orphanage was to split the children up according to their ages into 6 groups, 3 of boys and 3 of girls, and no attempt was made to keep families together. Each group had a living room where the children had their meals and pursued their day-time activities and a dormitory where they slept in very crowded quarters. There was a playground where the children spent their spare time in fine weather. Two women were in charge of each group of children and they were responsible for them day and night. The children attended the local Protestant and Roman Catholic schools.

The daily routine before the experiment began started with breakfast at 7:15. It consisted of bread with a smear of butter or jam and "ersatz" coffee, without any milk, to drink. The children had to be at school at 8 a.m. They went back to the orphanage for the mid-day meal, which consisted of vegetables or vegetable soup. The week's meat ration, about one ounce of cooked meat for each child, was eaten for dinner on Sunday. This meat was not always available. The last meal of the day was at 5:30 p.m., when the children had bread with a little butter, sausage, fish or cheese. On 5 days of the week "ersatz" coffee without milk was served as a drink, but on Wednesdays and Sundays they had sweet soup made from milk, water, semolina, and sugar. The whole of the milk supply for the week went into these two sweet soups. The amount of milk each child received varied from a half to one pint a week. The older children were entitled to less than the younger ones on their rations, but they got bigger helpings of soup and therefore more milk. The milk was almost always skimmed.

The bread which was available on the German rations and which the children had been eating before the experiment started was made mainly from wheat, though other cereals were added from time to time. It was a dark brown and contained more germ and bran than wholemeal bread, for part of the semolina was removed in the milling of the wheat and was sold as a food for babies.

Since one of the objects of the investigation was to study the sufficiency or otherwise of the B vitamins in the various experimental diets, it seemed unwise to have the children too plentifully supplied with these vitamins before the experiment began. For a preliminary period of 2 months, therefore, we replaced the German flour and bread with flour of 70 percent extraction or bread made from it. We did not change the allowance of bread to each child, so that they were still not getting quite enough to eat. The flour for making this bread was milled in England and sent to Germany for the experiment. This preliminary period was very valuable, for it gave us an opportunity to become familiar with the running and organisation of the Home, particularly the feeding arrangements, and to overcome any difficulties before the main investigation began. It also provided time for us to make all the preliminary examinations of the children.

After this preliminary period we divided the children into five groups, which were as similar as we could make them as regards sex, age, size and clinical condition. We then replaced the limited ration of bread by unlimited amounts of bread made from one of five different experimental flours. Each group was assigned a special flour. The flours were enriched with calcium carbonate. The children still had the meat, fish, milk, cheese, fat, sugar and vegetables to which their German rations entitled them, and these were cooked in the usual way and at the usual times; all through the investigation we tried to interfere as little as possible with the arrangements in the Home. All the children had daily supplements of 2000 I.U. of vitamin A, 1000 I.U. of vitamin D, and 25 mg. ascorbic acid.

Table 1 describes the five experimental flours. Calcium was added to all of them, most to the 100 percent extraction flour because it contained the most phytic acid and least to the three flours of 70 percent extraction. To avoid any chance of confusion between the enriched and unenriched 70 percent extraction flours and breads, the two enriched flours were colored yellow with turmeric. Number 4 contained 0.25 and number 5, 0.1 g./lb. The chemical composition of the five flours is shown in Table 2.

The bread was baked from these flours in a German bakery near the orphanage. Bread was available at every meal in unlimited amounts. We provided a little jam to make the bread more appetising, but it was always spread very sparingly. By a little internal rearrangement, which was made possible by the cooperation and goodwill of all concerned, the children in each bread group ate in a different room. We also

made the revolutionary change of having boys and girls eating together. The two German staff who were responsible for the children normally inhabiting each living room took over all the children eating a particular kind of bread at mealtimes, and they watched the children throughout each meal. The children soon developed a sense of loyalty for their bread and when we took some of them to the local zoo with a parcel of bread scraps, each child instinctively picked out a piece of his or her own sort to give to the animals.

Table 1. Description of the experimental flours

Group	Extraction rate, percent	Enrichment with Ca	Enrichment with thiamine, riboflavin, nicotinic acid and iron
1	100	37 oz. $CaCO_3$ per 280 lbs. or 0.33 g. Ca per 100 g.	None
2	85	17 oz. $CaCO_3$ per 280 lbs. or 0.15 g. Ca per 100 g.	None
3	70	10 oz. $CaCO_3$ per 280 lbs. or 0.09 g. Ca per 100 g.	None
4	70	As 3	Up to amounts in 100% extraction flour
5	70	As 3	Up to amounts in 85% extraction flour

Table 2. Composition of the experimental flours

	Extraction rate, percent				
	100	85	70	70 enriched to 100	70 enriched to 85
	grams per 100 grams				
Moisture	11.80	12.20	12.40	12.40	12.40
Protein (N x 5.7)	12.00	11.80	10.90	10.90	10.90
Fat	2.90	2.80	1.90	1.90	1.90
Calcium (including added calcium)	0.38	0.19	0.11	0.11	0.11
	micrograms per gram				
Iron	44.00	28.00	17.00	42.00	27.00
Thiamine	4.10	3.40	1.50	4.10	3.40
Riboflavin	1.52	0.81	0.46	0.98	0.71
Nicotinic acid	50.00	29.00	19.00	56.00	34.00

During the whole of this experiment a British dietitian and a trained nurse were attached to the Home and it was their responsibility to see that nothing went wrong with the dietary side of the investigation. They supervised the German staff, ordered the right amount of bread, and cut it up. The bread was cut by an electric machine into slices of known weight and spread with a known amount of jam. The number of slices eaten by each individual child at every meal was recorded throughout the year. This recording was done by the German women in charge of the children and it was done with meticulous care. All other foodstuffs were given to the children in restricted amounts as their German rations and the internal economy of the orphanage allowed, and the dietitian kept a record of them every day. The only dishes made

from a number of ingredients were the vegetable and sweet soups. The amounts of the various ingredients in all of these soups and their final volumes were recorded so that their composition could be calculated.

It was, therefore, possible for us to work out what each child ate on every day throughout the experiment. To give a picture of the average diet of the average child in the orphanage over the year, the mean daily intakes of the various foods are set out in Table 3. The age of the average child fell between 9 and 10 years and the table also shows the amounts of the same foodstuffs eaten by British children of the same age before the war (Widdowson, 1947).

Table 3. Composition of children's diet in terms of foodstuffs (grams per day)

	German children	British children of similar age
Meat (cooked weight)	6	86
Fish (cooked weight)	11	25
Cheese	7	8
Milk	82 (skimmed)	450 (whole)
Butter and margarine	12	30
Jam	53	24
Sugar	5	78
Orange juice (canned)	20	0
Potatoes	168	113
Root vegetables	36	11
Green vegetables	63	28
Dried pulses	2	4
Fruit	13	142
Flour	470	127

The average amounts of total and animal protein and of fat, carbohydrate and calcium in these diets are given in Table 4. The amount of bread eaten naturally varied with the age and appetite of the child. Those under 10 years rarely ate more than 500 g./day while most of the big boys regularly ate 800 g. and some of them over 1000 g. The calorie intakes averaged about 2100 a day. The experimental breads provided all the children with more than 70 percent of their total calories and those who ate 800 to 1000 g./day with about 80 percent. The diet was not low in protein because it contained so much bread and so little fat and sugar (Table 4). Protein provided 12 to 13 percent of the calories, which is the proportion usually found in mixed diets. About two-thirds of the protein came from the experimental bread and the remainder from the vegetables and the small amounts of meat, fish, cheese, and milk. Of the total protein only 8 to 11 g./day were of animal origin. The children had had no more animal protein than this for the previous two years, so they could not have started this experiment with a store of those growth factors which are associated with animal foods, e.g. vitamin B_{12}. The diet was very low in fat. Calcium intakes compared favorably with those of British children, but this was only because calcium had been deliberately added to the flour and bread.

We kept the children under close observation throughout the year. During the preliminary period, before the main experiment began, we made measurements of height and weight and girth of various parts of the body. Each child was examined clinically by two doctors working independently, and a sample of blood was taken for the determination of haemoglobin, haematocrit, serum proteins, and serum P-cholinesterase. Radiological examinations were made of the gastrointestinal tract and of the bones, and the teeth were inspected. I myself weighed and measured all the children once

a fortnight during the year of the experiment, and they were examined clinically every three months. At the end of the experimental year all the examinations which we had made at the beginning were repeated. We also made studies on a few of the children of the intakes and excretion of nitrogen, minerals, and of the B vitamins.

Table 4. Protein, fat, carbohydrate and calcium in the diets (grams per day)

	German children			British children of similar age
Extraction rate of flour, percent	100.0	85.0	70.0	--
Total protein	73.0	65.0	61.0	65.0
Animal protein	8.0	8.0	9.0	42.0
Fat	29.0	26.0	22.0	92.0
Carbohydrate	401.0	378.0	397.0	287.0
Calcium	2.3	1.3	1.0	1.0

When we began this investigation we were fully convinced, along with everybody else, that the children having the bread made from unenriched white flour would not do so well as the others (McCance and Widdowson, 1956). We thought they might develop signs of B-vitamin deficiencies and we were ready to terminate the experiment at any moment should this seem to be necessary for the welfare of the children. As the weeks and months went by we realized more and more that our preconceived ideas had been wrong. The general wellbeing of all the children improved in a most remarkable way, whichever kind of bread they were eating, and we could detect no differences either in growth or health between the groups of children eating the different kinds of bread. A number of experienced doctors and paediatricians came from England and other countries to visit us in Germany after the experiment had been in progress for some time. They all agreed that the children were in excellent physical shape, and they could not pick out any individual children as belonging to a particular bread group. The results of all the special examinations led to exactly the same conclusions.

Figures 1 and 2 show the average gains in height and weight of the children in the 5 groups. The curves for height for the different bread groups are almost superimposed. There are small differences in the curves for weight, and the children who were eating the unenriched white bread gained slightly more weight than those eating bread made from flour of 85 or 100 percent extraction, but the difference is not significant.

At the beginning of the investigation the German children were about 5 percent below the average height and 8 percent below the average weight of "normal" American children of the same age and sex (O'Brien, Girshick and Hunt, 1941). During the course of the year they grew more rapidly than American children and Figure 3 shows the average heights and weights of all the children together, irrespective of the kind of bread they were eating, compared with the average heights and weights of American children of the same sex and age. The German children gained 1-1/2 times as much height and weight as they might have been expected to do in the course of the year, so that by the end of the experiment they were nearer the normal height and weight for their age than they had been at the beginning. They were still, however, not quite up to American standards.

The "bone age" of the children was below their chronological age at the beginning of the experiment, and during the year their bone age advanced as the height and weight increased, more rapidly than "normal" (Table 5). The diets, therefore, seem to have been satisfactory in this respect, as they were in other ways. There

was no significant difference between the bread groups as judged by the maturation of the bones during the year, so it seems that this also was not influenced by the extraction rate of the flour.

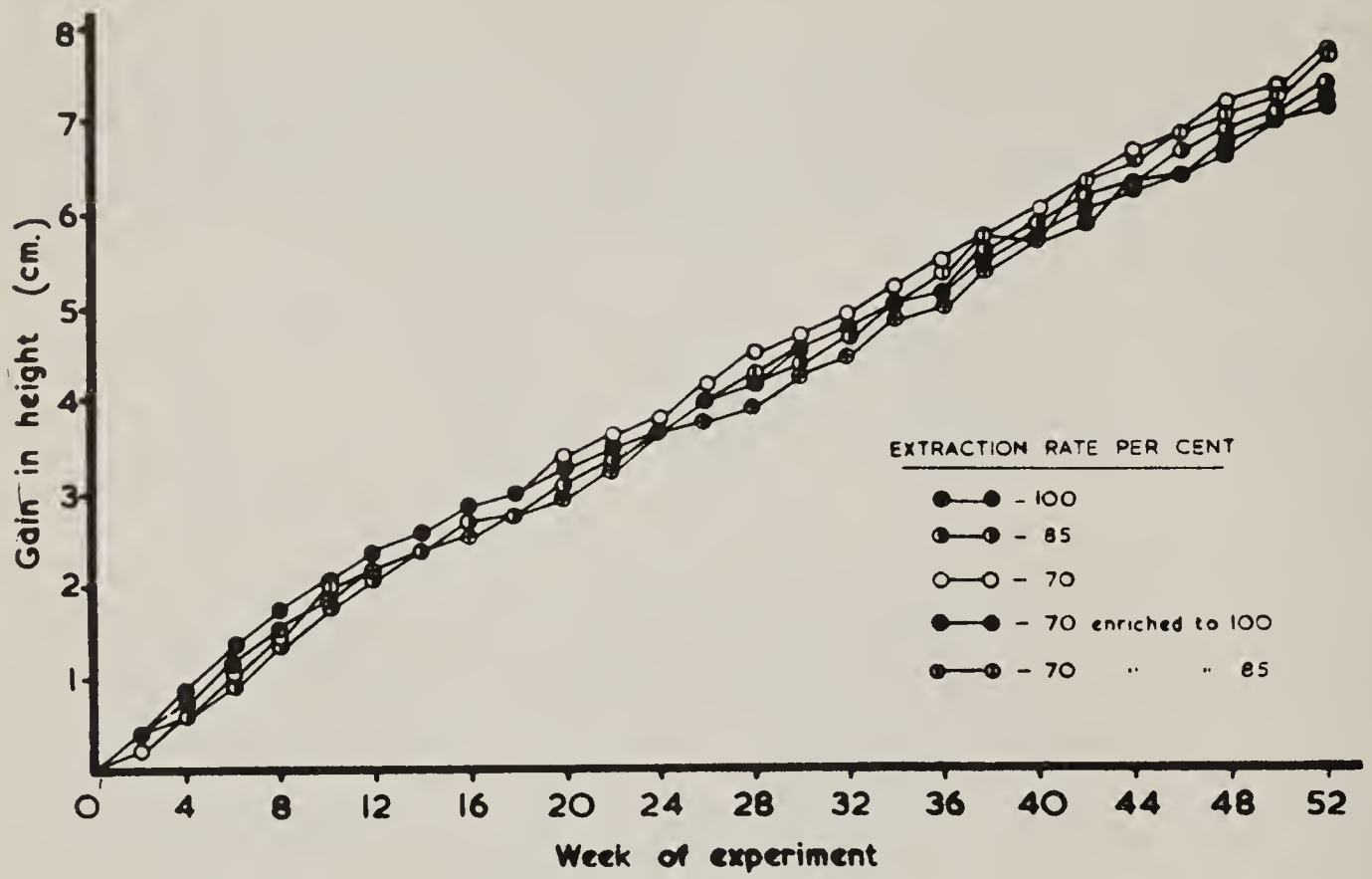

Figure 1. Average gains in height of children eating bread made from five different experimental flours.

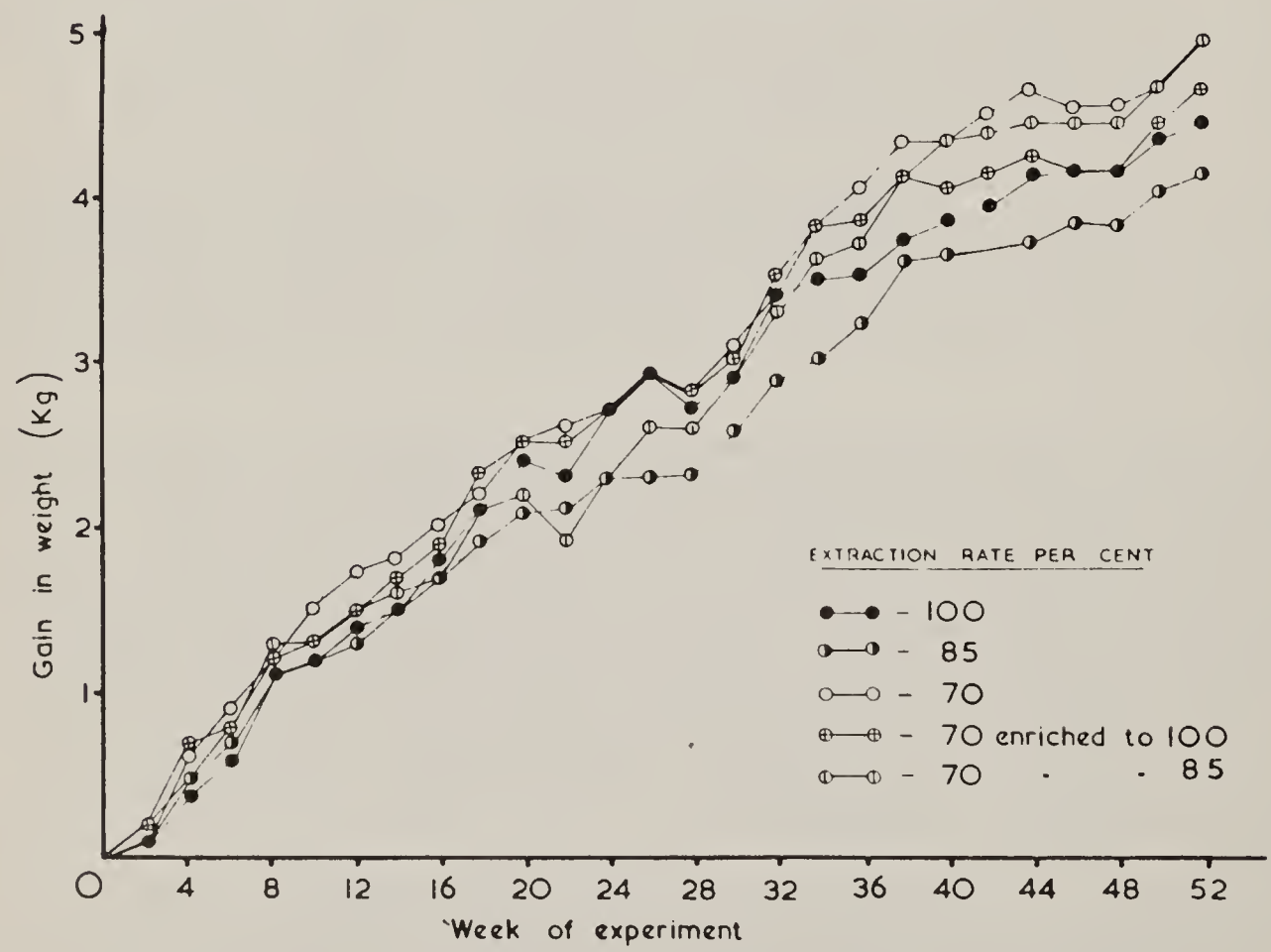

Figure 2. Average gains in weight of children eating bread made from five different experimental flours.

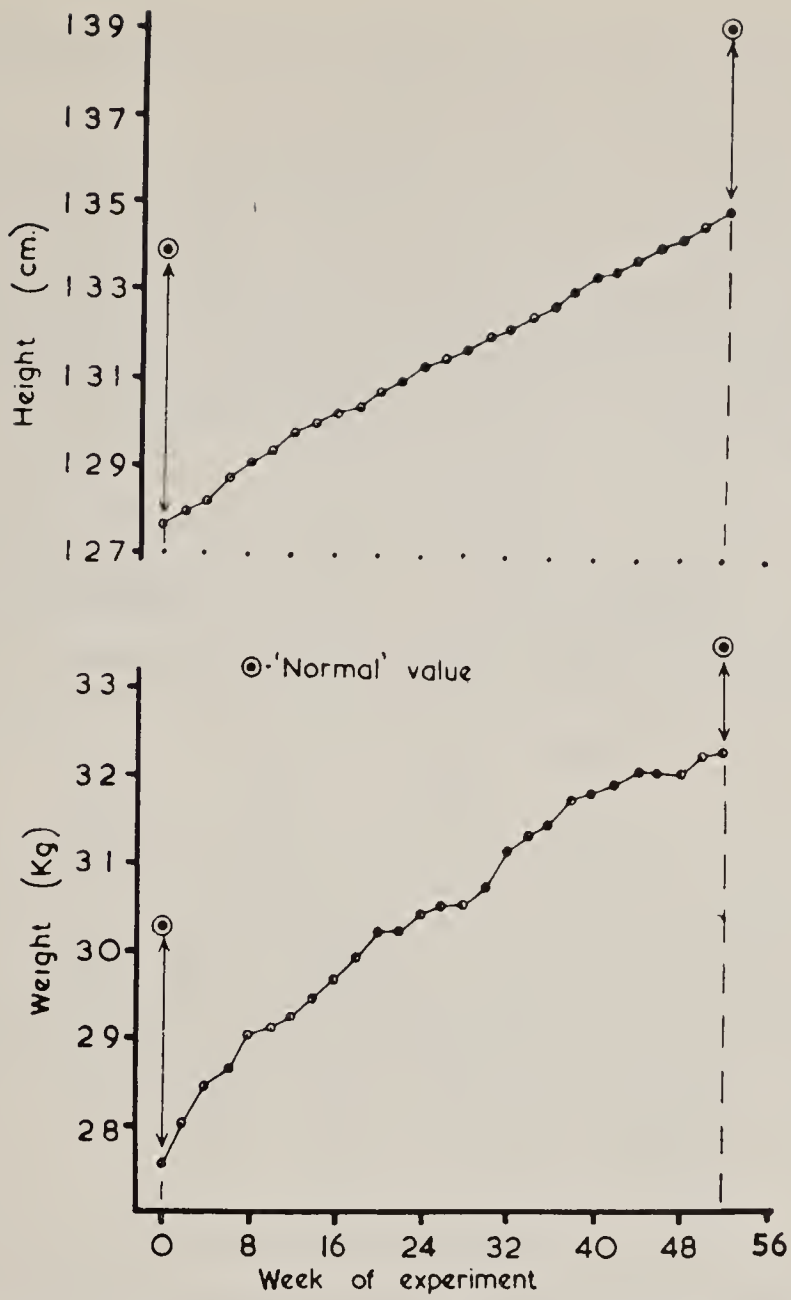

Figure 3. Average heights and weights of all the children eating bread made from experimental flours. The heights and weights of similar groups of "normal" American children are indicated, and the amounts by which the German children were below these "normal" values are shown by arrows.

Table 5. A comparison of the development of the children's bones with growth in height during the year of the experiment

	Retardation in "bone age" (months) deduced from X-ray photographs of the hand		Retardation in "height age" (months) deduced from the standing height	
	Beginning	End	Beginning	End
Boys over 10	15	6	12	7
Boys under 10	22	16	13	9
Girls over 10	16	11	14	9
Girls under 10	16	11	10	5

There were very few dental caries at the beginning of the experiment and the increase was trifling, whatever the kind of bread eaten. It was clear that the large

amount of bread did not do the teeth any material harm. The children were of course receiving adequate amounts of calcium and vitamin D.

Metabolic balance studies on all the children over the whole year of the experiment were quite out of the question, but we felt that some metabolic studies might be valuable as an additional assessment of the nutritional adequacy of the diets. We therefore chose 3 sample children from each of the bread groups and we measured their intakes and excretions of nitrogen, calcium, and of the B vitamins. These metabolic studies were made after the children had been living on the experimental diets for 3 to 7 months. One boy and two girls from each group were investigated. They were all about 13 years old.

Table 6. Intake, excretion and retention of nitrogen (grams per day).

Extraction rate of flour, percent	Intake			Excretion			Balance
	Bread and flour	Other foods	Total	Urine	Faeces	Total	
100	11.1	3.7	14.8	9.5	3.1	12.6	+ 2.2
85	9.1	3.6	12.7	9.3	1.7	11.0	+ 1.7
70	9.5	3.8	13.3	9.5	1.6	11.1	+ 2.2

Table 6 shows the average results for nitrogen. The figures for all nine children eating 70 percent extraction flour, whether it was enriched with B vitamins or not, have been averaged here. All the children were obtaining nearly two-thirds of their nitrogen from the experimental breads and flours, and on this diet they were able to maintain a positive balance of 2 grams of nitrogen a day, which was quite in keeping with the rapid gain in weight.

Table 7. Intake, excretion and retention of calcium (grams per day).

Extraction rate of flour, percent	Intake			Excretion			Balance
	Bread and flour	Other foods	Total	Urine	Faeces	Total	
100	1.90	0.62	2.52	0.22	2.07	2.29	+ 0.23
85	0.85	0.61	1.46	0.23	1.02	1.25	+ 0.21
70	0.59	0.64	1.23	0.24	0.68	0.92	+ 0.31

Table 7 shows the intakes, excretions and balance of calcium. The 100 percent extraction flour had been fortified with the most calcium and the 70 percent extraction flour with the least, which explains the difference between the intakes of the children eating them. At these levels of intake the balances were satisfactorily positive. We do not know what they would have been had the supplementary calcium not been added.

The intakes of thiamine and the urinary excretion varied with the extraction rate or the enrichment of the flour (Table 8). Foods other than bread and flour provided about 0.6 mg./day, which is a relatively large amount, and the total thiamine intake on the diet containing unenriched white flour was equal to or greater than the highest value for the requirement which has been proposed. The types of food available to the orphanage and the methods of cooking the vegetables and turning them into soups favored a high dietary intake of thiamine.

If the requirement for riboflavin is considered to be in the region of 0.5 mg. per 1000 total calories, then the riboflavin intakes of the children having unenriched

white bread were rather low, but their excretion in the urine did not suggest that there was any deficiency (Table 9). The faeces always contained more riboflavin than the food, which must have been the result of biosynthesis in the intestine. There is a suggestion from these results that synthetic riboflavin added to white flour was better absorbed than the vitamin naturally present in wholemeal bread.

Table 8. Intake and excretion of thiamine (mg. per day).

Extraction rate of flour, percent	Intake			Excretion		
	Bread and flour	Other foods	Total	Urine	Faeces	Total
100	1.64	0.60	2.24	0.61	0.65	1.26
85	1.27	0.59	1.86	0.39	0.72	1.11
70	0.62	0.65	1.27	0.17	0.46	0.63
70 enriched to 100	1.40	0.62	2.02	0.67	0.69	1.36
70 enriched to 85	1.23	0.60	1.83	0.37	0.72	1.09

Table 9. Intake and excretion of riboflavin (mg. per day).

Extraction rate of flour, percent	Intake			Excretion		
	Bread and flour	Other foods	Total	Urine	Faeces	Total
100	0.93	0.39	1.32	0.23	2.58	2.81
85	0.52	0.38	0.90	0.25	1.42	1.67
70	0.23	0.37	0.60	0.11	1.49	1.60
70 enriched to 100	0.55	0.41	0.95	0.28	1.47	1.75
70 enriched to 85	0.46	0.39	0.85	0.28	1.23	1.51

Table 10. Intake and excretion of nicotinic acid derivatives (mg. per day).

Extraction rate of flour, percent	Intake			Excretion		
	Bread and flour	Other foods	Total	Urinary acid-hydrolysable nicotinic acid	Urinary N-methyl-nicotinamide	Nicotinic acid in faeces
100	27.9	8.0	35.9	0.9	7.0	17.0
85	13.3	7.8	21.1	1.0	4.8	6.1
70	8.1	7.2	15.3	0.8	5.2	2.7
70 enriched to 100	25.4	8.4	33.8	1.2	9.8	7.5
70 enriched to 85	15.4	8.0	23.4	0.9	6.6	2.3

The intakes of nicotinic acid exceeded the National Research Council allowance of 4.7 to 5 mg. per 1000 calories in all groups and, judging by the levels of excretion of N-methyl-nicotinamide in the urine, it looks as though the intakes in all the groups were adequate (Table 10).

We started this investigation with the object of comparing the effect of different extraction rates and of enrichment with B vitamins and iron on the nutritional value of wheaten bread for children. We found no difference between the nutritional value of any of the breads, and since the children grew satisfactorily

on all of them and we could detect no signs of deficiency, we concluded that the diets supplied the children with all the known and unknown nutrients they required for the period of the experiment.

In 1926, Corry Mann published the results of an investigation into the effect of a milk supplement on the growth of children, and from that time onwards the idea has grown up in Britain, and I believe in the United States also, that milk is an essential for good nutrition. Only a diet which cannot be made to promote better growth by supplementing it with milk can be considered fully adequate. The excellent growth of the German children on diets to which wheat contributed 75 percent of the calories and which contained very little milk or animal protein made us wonder whether this growth could be improved still further by milk. We therefore decided to prolong our stay in Germany for a further 6 months and put this to the test. All the children over 5 years of age who were living in the orphanage in June, 1948, when the experiment I have just described came to an end, were included in this second investigation. Most of them had already taken part in the first investigation, but a few had been admitted to the Home at some time during the year. These had been eating one or other of the experimental breads, and the same foods as the others, but their records have not been included in the results I have shown you because the children were not there for the whole of the 12 months.

We now split up the original five groups and divided all the children in the orphanage into two groups, as alike as possible as regards age, sex, height, weight and clinical assessment, and as to whether they had previously taken part in the comparison of extraction rates or not. Each new group included equal numbers of children from each of the 5 previous bread groups. The "milk experiment" lasted for 6 months, from June to December 1948. Since we had already shown that children did equally well whichever bread they ate, we decided to use only one kind of flour for making the bread for this experiment. We chose flour of 85% extraction because this was in general use in England at the time and was most readily available. As before, all the children had their German rations except for the cereals and they all had unlimited amounts of bread made from flour of 85% extraction, fortified with calcium carbonate as before, and we supplied sufficient jam to spread sparingly on the bread. Each child in the milk group received 500 ml. of whole milk during the day, reconstituted from full cream milk powder. We reckoned this provided 330 calories and it was additional to the small quantity of milk which was included in the German rations. It was given in two parts, half in the morning and half when the children came back from school in the afternoon. It was served apart from meal times.

The children in the control group had only the milk provided by their German rations, which amounted to 60 to 120 ml. a day. They had as a supplement plain biscuits, made from the experimental flour, sugar and margarine, together with a drink of orange juice, made up from concentrated orange juice and water. The total calorie value of their supplement was also 330 calories a day. We added sufficient calcium carbonate to the orange juice to make the calcium intakes of the children in the control group equal to those of the children in the milk group, but this was probably not important because they were getting ample calcium from their fortified bread. Supplements of vitamins A and D and ascorbic acid were given as before.

Table 11 shows the average composition of the diets eaten by the two groups of children. The control diet was very similar to those eaten by all the children in the first investigation except that there was more fat in it. This came from the margarine used in making the biscuits. The supplement of milk trebled the intake of animal protein. There was no significant difference between total calorie intakes of the children in the two groups, and it is evident that the milk supplement did not specifically increase the children's appetites.

Table 11. Composition of the diets (grams per day)

	Milk group	Control group
Total protein	73.00	61.00
Animal protein	27.00	9.00
Fat	46.00	41.00
Carbohydrate	346.00	371.00
Calcium	1.83	1.3 + 0.53 added to orange juice

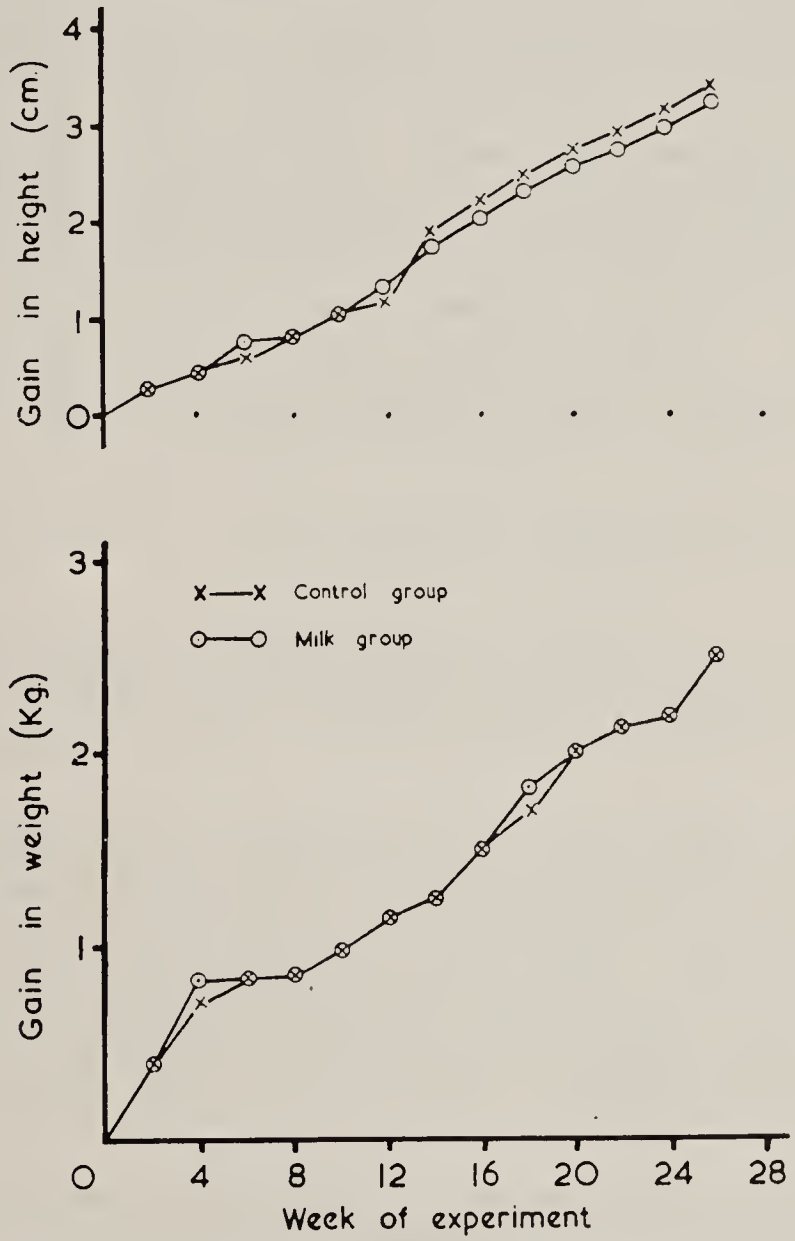

Figure 4. Average gains in height and weight of the children in the milk and control groups over the 6 months of the investigation.

We weighed and measured all the children every fortnight as before and examined them clinically at the beginning and after 3 and 6 months. Since most of the children who took part in this experiment had already taken part in the first investigation, they had already improved greatly in physique before the experiment began. There was, therefore, not the astonishing improvement noted a year earlier, for this had already taken place, but the same number of children were upgraded clinically at the end of the 6 months in each group. Figure 4 shows the average gains in height and weight. The curves for the two groups could hardly be more alike, and the children having the supplement of milk certainly grew no faster than the others.

Why were these results so different from those of previous investigators? Why have previous investigators almost invariably increased the growth of children by supplementing the diets with milk, while we did not? The difference must lie either in the quantity or quality of the basal diet or in the composition of the dietary supplement with which the milk supplement has been compared. Many previous investigators gave no supplement to the control group, or if they did they made it a placebo and of little or no nutritional value. Better growth of children having milk was interpreted as showing the special value of milk, but many other foods might have given just as good a response, and all that can be said with certainty is that the various basal diets must have been nutritionally unsatisfactory.

In the pioneer experiment of Corry Mann equi-calorific amounts of various foods were given as supplements to different groups of children. The basal diets at the Home where Corry Mann was working, however, provided very little calcium, and milk was the only one of the supplements which contained much. In this instance calcium may have been the important supplement. The basal diet at Duisburg supplied the children with all the calcium and vitamin D they could have required, and our investigation is the only one in which a milk supplement has been added to a diet known to contain plenty of calcium and vitamin D. The German diet seemed to us to be critically short of animal protein, and we thought that the milk would act, if it did act, by correcting this. We must conclude that the mixture of amino acids which the children obtained from their wheat flour and vegetables was not deficient in any respect. It is of course possible that the small amounts of animal foods in the diet were very important, particularly as a source of vitamin B_{12}.

What are we to conclude from these investigations? I can do no better than quote the conclusions which were published at the time.

"The first conclusion to be drawn from this report is unquestionably that the greatest caution must be exercised in coming to any conclusion at all. Any conclusions that may be drawn must be restricted to the setting in which the scientific evidence was obtained.

"Under the particular conditions of the experiments reported here no difference could be detected between the nutritive value of the different breads. Probably the most important finding concerns the high nutritive value of wheat in any of the forms customarily consumed by man. Thus it has been shown that diets in which 75 percent of the calories were derived from wheat flour and 21 percent from vegetables, and which contained only 8 grams of animal protein a day, provided undernourished children aged 5 to 15 years with all the nutrients required for a high rate of growth and development for a period of 18 months.

"The addition of 500 ml. of reconstituted full-cream dried milk per day over a period of 6 months caused no apparent improvement in the growth or health of the children. It is evident that diets containing much bread and little animal protein can be made highly satisfactory, and that a balanced diet, adequate in all its nutritional aspects, can be provided with minimal amounts of milk and meat, if plenty of wheat and vegetables are available."

REFERENCES

Corry Mann, H. C. 1926. Diets for Boys During the School Age. Med. Res. Council Spec. Rpt. No. 105, London.

McCance, R. A. and Widdowson, E. M. 1956. Breads White and Brown. Pitman Medical Publishing Co., Ltd., London.

O'Brien, R., Girshick, M. A. and Hunt, E. P. 1941. Body Measurements of American Boys and Girls for Garment and Pattern Construction. Dept. Agri. Misc. Pub. No. 366. Washington, D. C.

Widdowson, E. M. 1947. A Study of Individual Children's Diets. Med. Res. Council Spec. Rpt. No. 257, London.

Widdowson, E. M. and McCance, R. A. 1954. Studies on the Nutritive Value of Bread and on the Effect of Variations in the Extraction Rate of Flour on the Growth of Undernourished Children. Med. Res. Council Spec. Rpt. No. 287, London.

THE POTENTIAL OF WHEAT FOR MEETING MAN'S NUTRIENT NEEDS

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I wish to begin with the information compiled by Dr. Bennett in 1941 (Table 1). This may be well known to those primarily concerned with cereals, but it is impressive to realize that most people in the world derive about 80 percent of their food calories from cereals. Although these figures are over 20 years old, it appears that in most of the world food production has made relatively little gain as compared to the population (1,2,3), so that the general situation must be similar at this time. We do not know how adequately these people are fed, but we do know that many are badly fed. Even so, such figures do indicate the ability of cereals to meet the nutritional needs of man.

Table 1. Percentage of calories from cereals (including cassava) (1)

%	Countries	Total population, millions
30-40	U.S.A., Canada, United Kingdom, Sweden, Switzerland, Austria, New Zealand	205
40-50	Netherlands, Germany, Denmark, Norway, Australia, Finland	93
50-60	Eire, France, Belgium, Czechoslovakia, Hungary Estonia, Latvia, Argentina, Uruguay	93
60-70	Portugal, Spain, Italy, South and Central America (except Argentina and Uruguay), Union of South Africa, Newfoundland	204
70-80	Poland, Bulgaria, Yugoslavia, Morocco, Algeria, Tunisia	156
80-90	Rumania, Russia, Rest of Africa, India	1344 1/

1/ Russia based on 1928 statistics.

In general, areas with the highest cereal consumption are those with the worst economic condition. High cereal consumption is equated with poverty. One point I want to make is that if countries can develop a high degree of culture and a considerable ability to produce with diets of this kind, and with practically no application of nutrition planning or public health, there is little doubt that diets such as these could be much improved with the application of what we know today.

The other point that needs to be made is that cereal products in general are so-called "low prestige foods." As economic conditions improve, cereal consumption falls (Table 2). In the past all of us were wholely convinced that this was good evidence of man's instinctive preference for a "better" diet. Newer evidence indicates that this may well be an oversimplification of a complex situation. I shall return to this point later.

The science of nutrition is based largely upon the belief that the value of a diet to man is measurable in terms of the nutrients it contains. We support this belief in many ways, the most impressive being that having identified the essential

nutrients over the past 30 years, we can now concoct mixtures of synthetic or pure chemicals which are capable of supporting growth and good health in experimental animals. Furthermore, many diseases in man have been identified as deficiencies of specific nutrients and these respond to the appropriate chemical. Some experiments are available with infants over limited periods fed essentially purified diets. There is no reason to believe that man's nutritional requirements are particularly more complicated than those of experimental animals. Some data are available upon the amount of the essential nutrients required.

Thus the universal method of evaluating a diet is to compare the amounts of essential nutrients it contains with the amount that man needs. I should like to assume, simply for purposes of comparison and discussion, that a few individuals ate nothing but wheat or 80 percent extraction flour--that is, that they consumed sufficient of this to meet their caloric requirement--and then compare the other nutrients they would receive with certain dietary standards. The composition of wheat and flour vary, of course, and I do not wish to defend the figures I have chosen. A more serious problem is the selection of the dietary standard. In spite of the fact that you might expect nutritionists to agree at this time upon how much protein or a particular vitamin is necessary, the standards vary considerably. I do not have time to discuss the reasons, but I should like to come back to this subject briefly later.

Table 2. Comparison of nutrient standards and content of wheat (7-year child consuming 1800 calories)

Nutrient	Canada Std.	FNB Rec.	80% Flour	Whole wheat
Protein, g.	45	60	59	72
Calcium, g.	1.0	1.0	0.14	0.22
Iron, mg.	6	10	6.4	18.0
Vitamin A, IU	1600	3500	0	0
Thiamin, mg.	0.55	1.10	1.3	3.0
Riboflavin, mg.	0.90	1.50	0.35	0.63
Niacin, mg.	5.5	11.0	9.8	23.0
Vitamin C, mg.	30	60	0	0
Vitamin D, IU	400	400	0	0

Consider first a child 7 years old who is assumed to require and to consume about 1800 calories. The Canadian Dietary Standard (4) is given in the first column, the Recommended Allowances of the Food and Nutrition Board (5) in the second. The nutrients contained in 1800 calories of 80 percent extraction flour and in 1800 calories of whole wheat are given in the third and fourth columns. Wheat contains negligible amounts of vitamins A, C, and D. Obviously it is a diet not compatible with life. These nutrients must be supplied from other sources. However, it is of interest that the amount of total protein is similar to the FNB Recommended Allowance or above, and considerably above the Canadian standard. This comparison ignores the recommendation that some of the protein ought to be supplied from animal sources. Nevertheless, it is of interest that products of this kind contain respectable amounts of protein although they are generally considered to be deficient in protein.

The calcium content is very low. It is worthwhile to emphasize here that there is a considerable body of opinion that the recommendations for calcium may be unreasonably high. Also calcium carbonate would be one of the cheapest nutrients that one could supply. The thiamin and niacin contents would be well supplied. The figures for thiamin in particular would be much less if 70 percent extraction flour was used and would then be considerably below requirements. The riboflavin problem is apparently more serious. Riboflavin deficiency is generally reported to be common in much of the world. The minimum need for riboflavin is considerably less than the recommended amounts, however, and the evidence as to need is conflicting.

Similar calculations for individuals of different ages and sexes reveal essentially the same thing (Tables 2,3,4,5). However, the requirements for most nutrients are believed to decrease, relative to calories, in adulthood so that high cereal diets appear relatively more adequate for adults than for children.

Table 3. Comparison of nutrient standards and content of wheat (14 year boy, consuming 3000 calories)

Nutrient	Canada std.	FNB rec.	80% Flour	Whole wheat
Protein, g.	70	85	98	120
Calcium, g.	1.5	1.4	0.20	0.37
Iron, mg.	12	15	11	30
Vitamin A, IU	3300	5000	0	0
Thiamin, mg.	0.85	1.6	2.1	5.0
Riboflavin, mg.	1.4	2.1	0.6	1.1
Niacin, mg.	8.5	16	16.5	39
Vitamin C, mg.	30	90	0	0
Vitamin D, IU	400	400	0	0

Table 4. Comparison of nutrient standards and content of wheat (adult woman consuming 2300 calories)

Nutrient	Canada std.	FNB rec.	80% Flour	Whole wheat
Protein, g.	50	58	75	92
Calcium, Gm.	0.45	0.8	0.15	0.28
Iron, mg.	12.0	12.0	7.5	23.0
Vitamin A, IU	3200	5000	0	0
Thiamin, mg.	0.55	1.2	1.6	3.8
Riboflavin, mg.	0.90	1.5	0.45	0.8
Niacin, mg.	5.5	12.0	12.5	30
Vitamin C, mg.	30	70	0	0
Vitamin D, IU	0	0	0	0

Table 5. Comparison of nutrient standards and content of wheat (adult man consuming 3200 calories)

Nutrient	Canada std.	FNB rec.	80% Flour	Whole wheat
Protein, g.	60	70	105	128
Calcium, g.	0.65	0.8	0.21	0.39
Iron, mg.	6	10	11	32
Vitamin A, IU	4600	5000	0	0
Thiamin, mg.	1.1	1.6	2.3	5.3
Riboflavin, mg.	1.7	1.8	0.6	1.1
Niacin, mg.	11	16	18	42
Vitamin C, mg.	30	75	0	0
Vitamin D, IU	0	0	0	0

Proteins are required to supply the essential amino acids as well as the total nitrogen requirement. As I have indicated, cereals are generally considered to be poor sources of protein and the protein is of rather poor quality. That is, the

supply of some of the essential amino acids is relatively low compared to others. In Table 6 amounts of the essential amino acids supplied by wheat diets are compared with the minimum estimates of amino acids needed. The later figures are derived from the report of the FAO expert committee on protein requirements (6). In every instance, the diets supply considerably more than the estimated minimal amount. Wheat protein is low in lysine but even this amino acid is supplied at least twice the estimated minimum when the caloric needs are met.

Table 6. Comparison of FAO minimal amino acid requirements and content of wheat diets

Amino acid	7 yr. child 24 kg.		14 yr. boy 49 kg.		Adult woman 58 kg.		Adult man 70 kg.	
	FAO min.	80% Flour 1800 cal.	FAO min.	80% Flour 3000 cal.	FAO min.	80% Flour 2300 cal.	FAO min.	80% Flour 3200 cal.
Isoleucine	.71	3.1	1.64	5.1	0.97	3.9	1.18	5.5
Leucine	.82	4.5	1.87	7.6	1.10	5.8	1.34	8.2
Lysine	.71	1.7	1.64	2.9	0.97	2.3	1.18	3.2
Phenylalanine	.48	3.6	1.10	6.0	0.64	4.6	0.78	6.5
" + Tyrosine	.98	5.2	2.20	8.8	1.28	6.7	1.56	9.5
Methionine	.37	1.0	0.86	1.6	0.51	1.2	0.62	1.8
Total S. AA	.71	2.5	1.64	4.3	0.97	3.3	1.18	4.6
Threonine	.48	1.9	1.10	3.2	0.64	2.5	0.78	3.5
Tryptophan	.24	0.67	0.55	1.1	0.32	0.85	0.39	1.2
Valine	.71	2.9	1.64	4.8	0.97	3.7	1.18	5.1

The primary question, therefore, is what do these calculations mean? A diet composed of practically all wheat or 80 percent extraction flour meets the theoretical needs for many of the nutrients, including protein, which is generally considered the primary reason for inclusion of animal products. The needs for vitamins A and C are relatively easy to meet with green vegetables and fruit, vitamin D by exposure to sunlight. With these supplied, there would be debate among the experts on whether the diet would be deficient in calcium and riboflavin. Most likely the calcium is too low and riboflavin is on the borderline.

The things I wish to emphasize are: (1) On a theoretical approach it is rather easy to derive a diet based almost entirely upon wheat which looks reasonably adequate. (2) Most people who have studied high cereal diets find them better than they anticipated. (3) We really won't know much about this until we have a lot of experience in areas where cereal consumption is high.

There are many stories about the inability of nutrition experts to predict a satisfactory diet. The best examples are experiences with army rations during the last war. These were apparently adequate by chemical examination, but the troops would not eat them. Obviously no diet is satisfactory unless it is consumed. On the other hand, it has been said that the rations our troops threw away were considered reasonably satisfactory by troops from some other countries. The only conclusion one can draw is that chemical examination of a diet may indicate some of its limitations and potential utility but only experience under the conditions in which it will be used and by the people who will use it can give the answer that is needed. "Acceptability" is based upon principles that are not understood at all except to a limited extent in the cultures we are very familiar with. This clearly means that when we talk about feeding peoples in other parts of the world we simply guess until we have the evidence required.

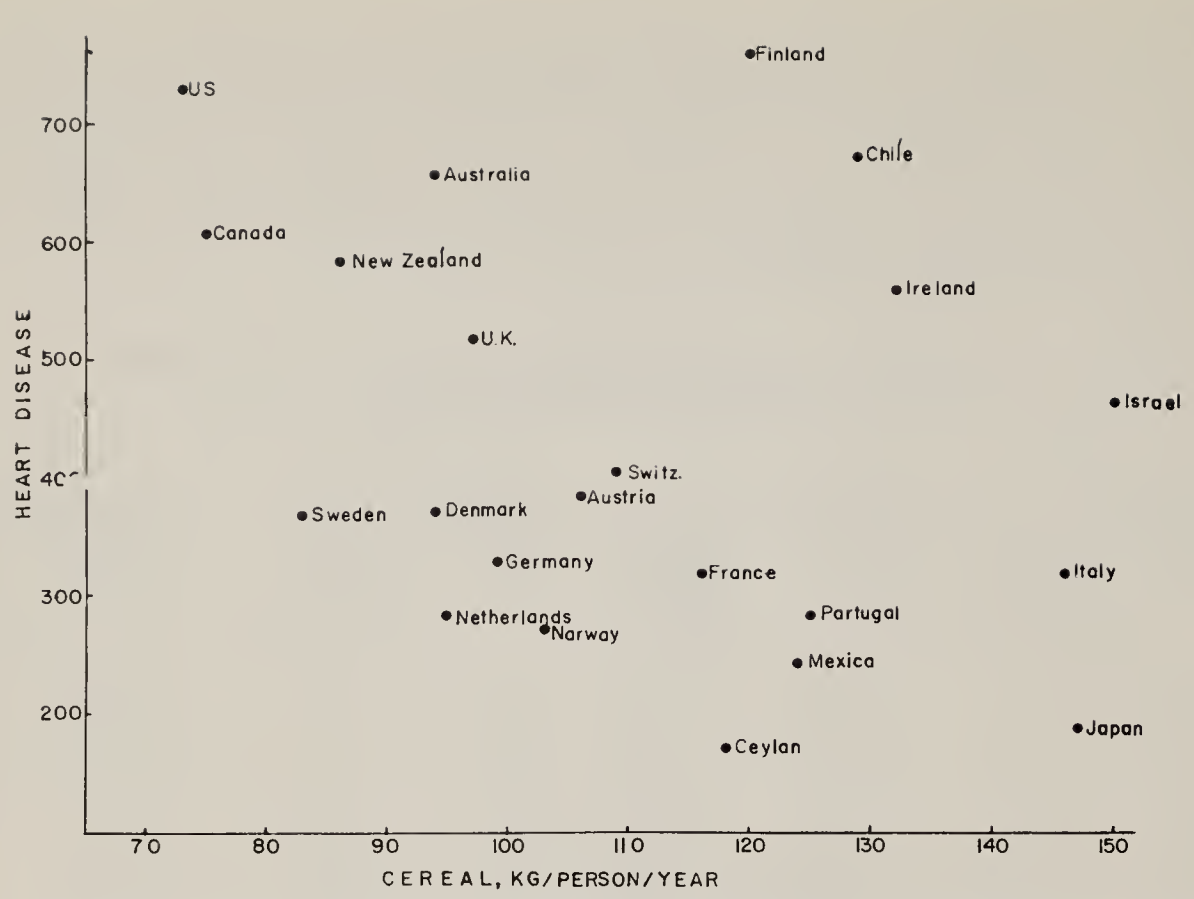

Figure 1. Age-adjusted rates of male heart disease vs. supplies of food cereals in various countries.

It is apparently true that in nearly every culture as economic conditions improve the cereal consumption falls. In Figure 1 I have plotted the age-adjusted rates of heart disease in males against estimates of the supply of cereals available for human consumption. The figures on mortality are taken from the publication of Yerushalmy and Hilleboe (7). The figures on supply of cereals are from the FAO report of 1961 (8). It is rather difficult to decide whether one should be impressed with the kind of information obtained or not. Overall there appears to be little relationship between these two variables. On the other hand, if one could remove Finland, Chile, Ireland and Israel from the plot, there would appear to be a reasonable inverse relationship. It must be remembered that the figures in certain countries may be subject to large errors and arrived at in somewhat different ways. Countrywide statistics may or may not be very meaningful. In the United States alone, mortality data from different states vary at least twofold and within countries there may be large differences in the food consumption as well as mortality data. Cereals available for consumption obviously do not necessarily mean that these amounts are consumed.

The thing that people usually plot is fat consumption versus heart disease. This amounts to the reverse of what I have plotted. If less fat is eaten, carbohydrate consumption must rise. Generally this means more cereal consumption, but additional potatoes and other starchy foods may be involved in certain countries. It is certain that a number of factors are concerned with coronary heart disease. Not only the amount of fat, but the kind of fat is probably more important. Exercise and many other variables are probably involved. Although it is generally agreed that we do not know all the answers as to the cause of coronary disease, the majority opinion of the experts in this field (9) is that diet is an important factor. Although they have not as yet been willing to recommend a general change in the diet of the U. S. population, they do suggest that a change is probably desirable for those who are believed to be susceptible to heart disease. Since about 50 percent of the men in the United States can be expected to die of this disease eventually, it would appear that this is only a temporizing conclusion. If current trends in research continue, the recommendation will have to be extended to practically the whole population. I have no particular argument with these conclusions at this time. One cannot tamper with the national diet without fairly

definite evidence. Nevertheless there is no particular sign at the moment for a need to reverse current trends. The population does in fact seem to be changing its diet. Whether this is entirely justified remains to be seen. The point I wish to make here is that if one lowers the fat intake, this almost automatically means an increased intake of cereals or other high carbohydrate foods.

I believe the importance of this to cereal producers is that it provides a positive nutritional attribute of cereals. You have been told so often that you had a poor nutritional product that you believed it. Furthermore, you did not work very hard or efficiently to disprove it, although evidence to the contrary has been around for a long time. In fact, it seems to me that most of the advertising associated with cereals implies a considerable lack of confidence in the product. The things other than cereals --vitamin supplements, protein supplements, etc.--which are added are the things usually stressed. The comparisons often made, such as a loaf of bread versus a pork chop, usually imply not much confidence in the bread. I feel that the cereal people should get on the ball and take a positive approach. The newer findings offer the opportunity and I believe that the bulk of evidence suggests that an increased cereal consumption in the United States would be desirable. This does mean that a long and established trend in nutrition will have to be reversed and this will not be easy. Furthermore, the meat, milk and egg groups are beginning a more vigorous support of their own interests.

I should like to point out that the organization of the Department of Agriculture and its research programs makes very little sense from the standpoint of nutrition. Practically everything is organized around commodity groups. The nutritionist sees every commodity group interested in pushing more of its commodity into human stomaches with no particular concern about the total diet. Wheat is a good food but it is not an adequate diet. The same can be said for every other food crop. The person interested in nutrition is, and has reason to be, skeptical of the commodity groups. Since there is little emphasis upon the total diet, we believe it is possible that any particular group may push their product to the detriment of the health of the people. Every commodity group will deny that they have this intention, of course, but they are rarely aware of the implications of their program in terms of over-all nutrition. It seems inevitable to me that increasing attention will be paid to this. Since the power now lies in the commodity groups, it seems that one of these will have to take the lead. Hopefully this will be the wheat group. We can see much sense in attempting to utilize local products plus wheat, soybeans, milk or whatever products are in surplus to yield optimum diets. We do not care to be closely identified with one product without adequate consideration of the total diet.

From everything we hear about the population explosion and agricultural programs in much of the world, we are led to believe that the overall food supply is not gaining upon the population and in many places is falling behind. Presumably this means that the United States will have the obligation and opportunity for many years to come to assist these countries. I think it is abundantly clear from the activities of the government in foreign aid in the past that giving aid places a responsibility upon us to know what we are doing and to have good programs. It has been argued that all we have to do is give them the food in some manner and it is their responsibility to utilize it. Fiascos in the past adequately demonstrate that it is not that simple. Poor programs reflect adversely upon all associated with them. Promotion of poor programs is bad business and morally wrong.

Programs for the disposal of food surpluses will almost certainly be limited to rather few products because of the supply and the transportation problems. Wheat will be a major one. The disposal programs should be viewed broadly as nutritional programs. As is well known, P.L. 480 contains provisions under section 104 (k) for nutrition research but little money has been alloted under this section and very little has been spent on nutrition. It is readily apparent that nutrition research has not figured very importantly in the minds of those who negotiate the contracts. I would like to

suggest, however, that P.L. 480 has been interpreted in a very narrow sense. Section 104(a) specifically allocates five percent of the total sales for market development. I submit that the best way to develop market is to demonstrate that the surplus commodity is being used to fulfill a nutritional need and that it is improving the health of the people. We should get rid of this word "research" since this is interpreted as some esoteric activity that has little or no relation to the intent of the law. Feeding trials, study of food consumption, demonstration of need and the ability of the product to fulfill that need, etc., should be activities basic to the development of markets. Considering the limitations in nutritional knowledge, the great differences in food habits, the differences in acceptability or nonacceptability of foods in different parts of the world, it is perfectly clear that only by experience in the field, under the conditions where the program will operate, can we be assured that a program is adequate. Theoretical considerations or experiences in one area may have little applicability in other areas, although this will become less true as our experience is broadened.

In summary, it is clear that wheat has great potential in meeting man's nutritional needs. However, any consideration of nutrient needs requires consideration of the total diet. Only limited inferences can be made from consideration of a single commodity. The potential will vary in time and place depending upon food habits, local customs, and other resources available. Thus only experience under specific conditions can be viewed as adequate. Considering current trends and prognostications for the future, the opportunities to gain this experience in many parts of the world should not be lost.

Discussions. Questions centered around the need and the potentiality of special dietary supplements for special groups such as young children, and the extent of reliance possible on correlations of serum cholesterol with dietary fat or conversely with grains.

International agencies have become convinced through actual investigations that there is a special dietary need in the case of post-weanling preschool children. They are difficult to reach separately for study, and it may be unsafe to assume that a general supplementation for the family needs would be adequate for this special group. There are considerable potentialities for special foods in the diet of the infant and preschool child; fish flour and other protein concentrates have much to offer.

Correlations such as that discussed in the presentation, though not too convincing when considered alone, are supported by other evidence. In order to get a definitive answer on the effect of diet change on mortality one would need to change drastically the diet of some 50,000 people and study the effects for 5 to 10 years. It is quite evident how difficult this would be.

REFERENCES

1. Bennett, M. K. International Contrasts in Food Consumption. Geog. Rev. 31:365, 1941.

1a. Bonner, J. The World's Increasing Population, Proc. Fed. Amer. Soc. Expt. Biol. 20, Sup. No. 7, p. 369, 1961.

2. Shaw, B. T. Prospective World Production and Distribution of Food, Proc. Fed. Amer. Soc. Expt. Biol. 20, Sup. No. 7, p. 373, 1961.

3. Sen. B. R. Problems of Food and Nutrition - Views and Programs of FAO., Proc. Fed. Amer. Soc. Expt. Biol. 20, Sup. No. 7, p. 384, 1961.

4. Canadian Council on Nutrition. A Dietary Standard for Canada. Canadian Bulletin on Nutrition. Dept. of Public Printing, Ottawa, 1950.

5. National Research Council, Food and Nutrition Board. Recommended Dietary Allowances. Publ. 589, Washington, D. C., 1958.

6. Food and Agriculture Organization of the United Nations Committee on Protein Requirements, Nutritional Studies No. 16, Rome, 1957.

7. Yerushalmy, J., and Hilleboe, H. E. Fat in the Diet and Mortality from Heart Disease, N. Y. State Journal of Med. 57:2343, 1957.

8. Food and Agriculture Organization of the United Nations, The State of Food and Agriculture, Annex Table 13A, p. 166, Rome, 1961.

9. American Heart Association Dietary: Fat and Its Relation to Heart Attacks and Strokes, Report by the Central Committee for Medical and Community Program, Circular 23:133, 1961.

ACTIVATING MARKETS FOR UNITED STATES WHEAT

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In considering my topic, which introduces a panel discussion, I have been impressed with the fact that any discussion of international trade in wheat must begin by taking into account the fact that recent years have seen the development of new economic, social and political situations which substantially affect the pattern which market development must take in these times.

Among the matters I have in mind are the following: (1) rapidly increasing population in the less developed countries, both communist and noncommunist; (2) failure of agricultural production in the less developed countries to expand as rapidly as population; (3) a large increase in agricultural productivity in the highly developed western nations resulting in an accumulation of heavy stocks of wheat, particularly in the United States; (4) an increase in the existing government controls over the handling of grain, particularly wheat, throughout the world; (5) inability of nations most deficient in food to secure foreign exchange or other means to purchase foods in the normal channels of trade.

A general recognition of the matters just mentioned has resulted in the development and acceptance of a philosophy which holds that the existence of surplus food in one part of the world coincident with shortages of food in other parts cannot be justified and accepted and that some means must be found to bring surplus food and hungry people together. While support of this idea might be expected in the less developed countries, it has also found wide acceptance in the western industrialized nations, although for obvious reasons the lion's share of doing something about it has fallen on the United States.

Also since the beginning of the cold war, food has been used increasingly by the United States as an instrument of foreign policy. Its effectiveness has been enhanced by the fact that agricultural production is still communism's greatest failure. This fact, together with the acceptance of the idea that surplus food should be put into the hands and mouths of hungry people, has made some change in the attitude of the American people toward our stocks of wheat and other storable commodities. Rather than regarding them as a burden and a liability many now think of them as an asset and a source of strength. It can be seen how fortuitous it has been that a tremendous upsurge of productivity on the part of American farmers has coincided with the increase in world population and its resulting drain on food supplies.

One cannot get very far into any discussion of market development for wheat without bringing in the Agricultural Trade Development and Assistance Act of 1954 usually referred to as P. L. 480. The enactment of this law followed a recognition of the fact that a new, timely and more effective approach to the problems of surplus disposal and market development was imperative. It was a carefully worked out piece of legislation, and the best evidence that it has met the need of the times is found in its repeated extensions, and in the fact that Congress has strengthened the law every time it has been extended. It is found in the fact that the legislation and its administration have never been a political issue. It was inaugurated under the Eisenhower Administration with the support of both Republicans and Democrats. The Kennedy Administration has not only accepted it *in toto* but has expanded and strengthened it, again with the support of both parties.

Now I want to take a little time to discuss some of the provisions of the act itself. I'll read the declaration of policy in full because every phrase in it

means something as far as the intent and purpose of the act is concerned. It reads as follows: "It is declared to be the policy of Congress to expand international trade among the United States and friendly nations, to facilitate the convertibility of currency, to promote the economic stability of American agriculture and the national welfare, to make maximum efficient use of surplus agricultural commodities in furtherance of the foreign policy of the United States, and to stimulate and facilitate the expansion of foreign trade in agricultural commodities produced in the United States by providing a means whereby surplus agricultural commodities in excess of the usual marketings of such commodities may be sold through private trade channels, and foreign currencies accepted in payment therefor. It is further the policy to use foreign currencies which accrue to the United States under this Act to expand international trade, to encourage economic development, to purchase strategic materials, to pay United States obligations abroad, to promote collective strength, and to foster in other ways the foreign policy of the United States."

Five separate and distinct programs are authorized under P. L. 480 as amended. Title I is the most important. It provides that payment for sales of surplus agricultural commodities to friendly countries may be made in the currency of the recipient country, and in certain cases outright grants are authorized. Title II authorizes government-to-government donations of Commodity Credit Corporation-owned commodities for emergency and work relief uses by the recipient country.

Two programs are authorized under Title III. One is barter. The other provides for donations to needy people in foreign countries through private United States relief and charity agencies, such as CARE and the several religious organizations engaged in such activities. The fifth program is authorized by Title IV and provides for agreements between our government and the governments of friendly countries for delivery of surplus agricultural commodities on credit up to ten years. Dollar payments with interest are required.

It is difficult in a discussion of this kind to describe the operations of P. L. 480 fully enough to comprehend their extent in detail. I shall not try to do so. The volume of transactions under Title I has been tremendous. Commitments up to date have been approximately $11,000,000,000. Many of these commitments still have from one to four years to run. Commitments under other phases of the program have been only a fraction of those under Title I in volume, but all of them have been important and have played a part in carrying out the objectives of the act.

I believe that P. L. 480 with all of its varied and far-reaching provisions constitutes the greatest instrumentality ever set up by Government to develop export markets for agricultural commodities. While it is related to many things including surplus disposal and the use of agricultural surpluses as an instrument of foreign policy, its basic long-range purpose is to develop permanent export markets for agricultural commodities in normal channels of trade as rapidly as this may become possible. In the meantime, in areas where this cannot be done now the methods provided, such as sales for local currencies, barter, long-term credits, and grants, are a way of bringing buyers and sellers together on a basis which is mutually agreeable and profitable.

It should not be forgotten that every country now purchasing under P. L. 480 provisions is a potential dollar customer. Secretary Freeman, when in India last fall, made the statement in effect that the time would come when India would be our greatest dollar market for wheat. Of course that is probably a long way off. However, two of our present best dollar markets--Japan and Italy--were concessional sales purchasers only a few years ago.

The P. L. 480 program has been especially effective for wheat. This is shown by the exports during the last four marketing years. For 1957-58 exports of wheat

including flour were 410 million bushels; for 1958-59 they were 440 million; 1959-60, 507 million, and for 1960-61, 662 million. So far in the present marketing year exports are above a similar period a year ago.

At present about one-third of our wheat exports are for dollars in the normal channels of trade. The remainder go out under the various concessional programs provided by P. L. 480. A small amount moves under the Mutual Security legislation administered by AID, formerly ICA. We hope for a steady increase in transactions in normal channels, as world economic conditions improve but realize that for a long time to come some of our wheat will move under concessional sales of one kind and another.

There are various ways in which P. L. 480 helps in developing markets, both concessional and those in normal channels of trade. One of them is by the use of foreign currency in carrying out market development activities. This has set the stage for a tremendous effort by Government and private industry in market development. In wheat this has meant cooperation between wheat grower's organizations and Foreign Agriculture Service, between millers and Foreign Agriculture, and to some extent between wheat growers and millers. Another important advantage is that under existing provisions of the law and regulations it is possible to plan market development activities with FAS one or more years in advance.

The fact that foreign currency funds were available for foreign market development encouraged wheat growers in seven states to set up state wheat commissions and to tax themselves to secure matching funds for market development activities (one state, Oregon already had a commission when P. L. 480 was passed). It led to the formation of two regional market development organizations, one in the great plains and the other in the Pacific Northwest. These two organizations working in close cooperation with FAS have initiated, or are now initiating, market development activities in every wheat importing country in the world. Third party cooperators, consisting of organizations, groups and individuals, have made a contribution also.

Now may I proceed to discuss briefly some of the problems which have confronted us in developing markets for wheat. Some of these are general, others relate particularly to sales in the normal channels of trade for dollars. Some of these problems are due to the fact that never until now has anything been done in the way of systematically developing permanent and reliable markets for our product. True, we have practically always exported some wheat--that is, we have been "an exporter of sorts." But we have been "in and outers," depending on the size of our crop, the crop in other exporting countries, and the net world demand.

Furthermore, unlike our neighbor to the north, we have not in the past, with few exceptions, studied the demand and needs of importing countries or made any definite efforts to produce the kind of wheat and wheat of the quality and condition to meet those needs. All this, in spite of the fact that our vast wheat producing areas enable us to produce practically every kind of wheat known to man.

Transportation costs have constituted a grave handicap especially in the Great Plains area, much of which is a long distance from ocean transportation. Over the years, rail transportation rates on grain have been out of proportion to the costs involved and to rates on other commodities.

One of our principal problems is that of trade barriers. I doubt if any commodity in international trade faces as many such barriers as wheat. There are various reasons, including national defense, but the principal one is that practically every wheat importing nation is also a wheat producer and is under pressure to take steps necessary to protect its own farmers. These steps take the form of tariffs, import quotas, milling quotas, exchange regulations, bilateral agreements and others devised to deal with some local or unusual situation.

In some areas where food shortages exist, people are not familiar with wheat as a food and do not have the facilities or inclination for putting it into edible form. This is particularly true in parts of Latin America and Asia. In this field much research is needed similar to what has already been done here at Albany. Lack of adequate funds constitutes a real handicap in this respect.

These obstacles, formidable as they may be, are not insurmountable. They should not make us faint-hearted. Rather they should be considered as a challenge. In fact, real progress is now being made in solving some of them.

And now to take up a more optimistic note, let us turn to some reports in the field of progress.

1. Substantial reductions have been made in transportation rates on export shipments.
2. Excellent working arrangements have been established with Foreign Agricultural Service and other governmental agencies for carrying out market development activities throughout the world.
3. Steps are being taken toward improving the kind and quality of wheat produced in the United States so as to meet requirements of foreign purchasers. This includes work with plant breeders in the improvement of varieties and financial inducements to growers to produce a quality product.
4. Educational programs have been carried out along technical lines to enable millers and bakers in foreign countries to make more effective use of U. S. wheat. Examples are the work of Ed Seeborg in Japan and Roy Durham in South America and Europe.
5. Nutrition programs have been set up in areas where the diet consists principally of inferior foods, but where wheat can be made available if desired. This includes use of specialty products like bulgur in its various forms.
6. An excellent understanding and interest in market development has been developed on the part of members of Congress. This has resulted in legislation strengthening the P. L. 480 program and in adequate appropriations for its continuation and expansion.
7. We have gone a considerable distance in developing a better understanding between producers and the grain trade and others engaged in the marketing and processing of wheat.
8. A substantial amount of work has been done in efforts to increase domestic consumption of wheat in the form of new food products and in utilization research covering new uses both for food and industrial purposes for domestic and export consumption.

This list could be extended, if time permitted.

Before closing, I want to take a moment to comment briefly on the development of new wheat food products for the domestic market. Efforts along this line should be expanded, but it should be remembered that in a nation whose people are as well fed as ours, per capita consumption of food is not likely to increase, rather the reverse. There may be shifts between commodities, however, and for certain health and medical reasons this is a good time to develop new forms of wheat for human consumption.

In conclusion I cannot forbear making one more point. It is that an expansion of our efforts to develop markets for agriculture has long been overdue. For more than fifty years we have had a constantly increasing program of production research, both public and private. It has been a great success. Its results are apparent in our bulging storage bins and in our government programs to curtail production. And even more severe curtailment may be in the offing. The answer does not lie in reducing production research. Except as a temporary measure (and even that is doubtful), it does not lie in curtailed production. With world conditions as they are today, the only program which makes sense on a permanent basis is research directed toward the development of new and improved products and means for introducing them into new markets. Then and only then will there be a full opportunity for wheat to play its rightful and needed role in the world's food supply.

OPPORTUNITIES FOR MARKETING WHEAT IN ASIA

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The third general subject on our program, Opportunities for Marketing Wheat Abroad, is directly related to the other two main topics: The World Supply and Usage of Food and The Nutritional Values of Wheat. The relatively low cost of wheat for food in the world because of an abundant supply and the superior nutritive qualities of wheat compared to rice are the two reasons there have been, and continue to be, tremendous opportunities for marketing wheat in Asia.

Before reviewing these opportunities with you and briefly describing our programs to date, perhaps it would be well to identify our organization. Western Wheat is a regional association representing the wheat growers through their commissions and associations in the states of Washington, Oregon and Idaho. We have the administrative responsibility for the wheat market development program in the Asian area where we cooperate with Great Plains Wheat and the Foreign Agricultural Service.

We use the name "Wheat Associates" to describe our joint efforts through our four regional offices located at Tokyo, Manila, New Delhi and Karachi. Full time area directors also service the smaller but still important markets of Korea, Hong Kong, Okinawa, Formosa, Thailand, Malaya, Indonesia, Ceylon and Burma. Our organization has its headquarters office at Portland, and a representative stationed in Washington, D. C. Our primary objective, simply stated, is to expand the market for United States wheat and wheat products.

You are all familiar with the saying, "You cannot see the forest for the trees." In Asia we could say, "You cannot see the opportunities for the people." More than half the world's population live in our area of responsibility. Sometimes it seems that these crowded millions with their low incomes and seemingly endless problems are a poor market risk. However, these people are forced to depend primarily on cereal grains as their principal food. Under these conditions, the Asian area offers the greatest opportunity now and in the near future for increasing the per capita consumption of wheat foods. For this reason, we can say that in Asia "the people are the opportunity."

Secretary of Agriculture Freeman, speaking during our staff conference at New Delhi last October, said two things that appear significant from the standpoint of future markets. First, that Department studies showed that by 1966 there would be a wheat food equivalent deficiency of cereal grains in the Asian area of 975 million bushels. Second, that in his opinion this area could well become the world's largest dollar market for wheat and other food grains within 25 years.

There are two different types of markets in Asia. When the Secretary was speaking at New Delhi, he was referring primarily to the under-developed countries such as India and Pakistan. These countries with their soft currencies have been purchasing large quantities of wheat, as most of you are aware, under Public Law 480. Some of you may wonder why we have offices in India and Pakistan instead of concentrating all of our efforts in the dollar markets like Japan and the Philippines. The tremendous size of the wheat import programs into these soft currency markets justifies our servicing them. Let's talk about India first.

India. India signed a P.L.480 agreement May 4, 1960, with the United States to import 16 million tons of wheat over a four year period. The wheat actually didn't start moving until November of that year. During the first year, about 4 million

tons of wheat was imported, but actually almost half of this came in under previous programs. By May 4, 1962, it is estimated that India will have imported about 4 million metric tons of wheat under the present program--or about half of the amount that was available. Even at a 50 percent rate, this amounts to some 150 million bushels over a two-year period. The principal reason imports have not been higher is the fact that two bumper grain crops have been harvested during the immediate past years, and storage facilities have not yet been provided for the proposed 4 million ton buffer stock.

Our activities in India have been described as primarily those of servicing a government program. We have furnished technical assistance on the storage, handling and inspection of the imported wheat. Market development projects in underdeveloped countries are not supposed to create additional demands that cannot presently be satisfied at least on a dollar basis. However, this brings us back again to the two major advantages for wheat foods. They are less expensive and more nutritious than the other major cereal grains. These two reasons explain why the governments of India and Pakistan favor the increased consumption of wheat foods in their rice eating areas.

India has a population of some 450 million people. The per capita income has now increased to about $70 per year. About one-third of the Indians living in the northern area are traditionally wheat eaters, consuming some 150 to 200 pounds of wheat per capita. Climatic conditions are such that in this area pulses such as chick peas and other legumes can also be produced. These higher protein cereals combine with wheat to provide a much better diet nutritionally than is available in the areas where the people consume primarily rice, bananas, coconuts and vegetables. Intense interest is now developing in India in the field of nutrition. A Nutrition Section has only recently been established in the Food Department--influenced, apparently, by our program.

Looking for opportunity? There are some 300 million people living in the rice eating area of India. The per capita consumption of wheat foods ranges to a low of two pounds per year. An increase of one pound per year in wheat consumption would require an additional 150,000 metric tons of wheat. An increase of ten pounds per capita per year would require an additional 1,500,000 metric tons--or about 55 million bushels. An increase to 100 pounds would require 15 million metric tons--or some 550 million bushels. You can have a lot of fun with figures when you're working with a population the size of the one in India.

In addition to technical assistance, we have had a bakers training program at the College of Catering in Bombay to develop technicians to prepare better quality products because better quality products will increase the demand. In the field of nutritional education we have contracted out nine mobile demonstration units with various community and state government organizations. A mobile demonstration bakery operates to improve the quality of bakery products through proper use of yeast. An exchange of trade teams and technicians has been an effective activity. Displays and exhibits have been used at trade fairs and small industry exhibitions. We have worked in an advisory capacity on school lunch programs with CARE and state governments and on payment-in-kind projects. Bulgur has been introduced as a new wheat food that appears highly acceptable in this area. These are examples of our market development activities.

Pakistan. Pakistan is similar in many ways to India. The country has a population of some 100 million people, divided between 45 million in the wheat eating area of West Pakistan and 55 million in the rice eating area of East Pakistan. The opportunity, again, is not in the wheat eating area where per capita consumption already is in the neighborhood of 170 to 200 pounds; but rather in the rice eating

area, where per capita consumption is low and the people need an inexpensive food that is better nutritionally than what they have. Figures are fun in Pakistan too, and a one pound increase in East Pakistan would require an additional 25,000 metric tons of wheat. A ten pound per capita increase would require 250,000 metric tons, and a 100-pound per capita requirement would use some 2,500,000 tons--or more than 91 million bushels.

Our activities in Pakistan have included technical assistance on storage, handling and inspections, the introduction of bulgur wheat, a pilot school lunch project, and exhibits and displays. Plans have been developed for a nutrition education program through demonstration units including a boat, and for the distribution of chakki wheat grinding mills in the rice eating areas.

Pakistan is in the first year of a four-year program to import about 55 million bushels of wheat under P.L.480 from the United States. Here, again, the size of the program justifies our servicing it. In addition, there is the tremendous opportunity of supplementing the diet in the rice eating areas with wheat foods because they are better nutritionally and less expensive.

The rice bowl countries. Burma, Thailand, Malaya and Singapore are known as the "Rice Bowl of the World." Burma and Thailand are the two leading rice exporting countries. Burma produces 7 million tons per year and exports 2 million. Sixty-five percent of the cropland in Thailand is devoted to rice production, and last year 1-1/2 million tons were exported. The governments of these two countries, naturally, are not interested in increased wheat consumption, but there is a slow steady increase anyway. To date, these have been principally flour markets, and the flour is imported into these countries at 100 percent duty.

It is now apparent that these markets will undergo considerable change in the next few years as flour mills are constructed. There are presently six modern roller mills in Burma. One mill is under construction in Bangkok, a mill is being planned for the Malay Peninsula, another mill is under construction in Singapore, and a mill is planned in Ceylon. Individually, these markets are small, but in the aggregate, they represent a 10 to 15 million bushel market; and the main type of wheat they will use will be soft white.

We have conducted activities of a survey-type nature in all of these countries. Technical assistance has been furnished in Burma, and plans are under way to set up a joint office with the Burma Flour Mills Association. Ocean transportation on small lots of wheat is expensive, and service is not readily available. However, when mills are in operation in all of these areas, cargos may be combined; in this way business may become more attractive to shippers.

Communist China. I think some reference should be made in these remarks to the influence on the United States of the shipments of large quantities of wheat and barley to Communist China by Canada and Australia. Canada to date has contracted 108 million bushels of wheat and 26 million bushels of barley. Australia has contracted at least 105 million bushels of wheat and flour plus additional barley. Information indicates the Chinese food position is still critically short. The sales of wheat by Canada and Australia have strengthened the world wheat market, thus benefiting the United States. Recognizing this fact, our wheat growers are still interested in the possibility of sales to this market as long as other members of the Western Bloc are benefiting from this commerce. We realize that United States policy towards Communist China is different from that of Canada and Australia--also, that changes in this policy must be directed by our State Department. Meanwhile, however, we are keeping well informed on the needs of this country and the effect of sales by our friendly competitors on the world wheat market and on their own domestic wheat programs.

Our principal dollar market - Japan. Japan is our principal dollar market in Asia. We opened our first market development office here in 1956. Our original objective was to expand the total market for wheat foods. This has been generally effective. Even last year in the face of the largest rice crop in the nation's history, the consumption of flour products increased about 10 percent. Unfortunately, United States wheat sales to this market have decreased during the past five years due to the increased demand for high protein bread wheats and the increased production of locally produced soft wheat.

It takes time to change direction of a market development program. About two years ago we switched to a hard sell for U.S. wheat to gain a larger share of the market. This coming year we expect to see a sizable increase in United States' shipments of wheat to Japan. The Japanese are particularly interested in finding an alternative source of imports for bread wheats instead of being completely dependent (as they have been during the past few years) on Canada. The major problem is that most of the U.S. hard wheat stocks are located in the Great Plains area and are not presently available in export position from the West Coast.

Total consumption of wheat in Japan for both food and feed during this next year will approach 5 million tons. Estimates are that within the next five years this could increase to almost 7 million tons. Local production of wheat in Japan is not expected to increase much beyond 2 million tons. So, within five years there should be an opportunity for sales of about 5 million tons of wheat to Japan compared to present imports for food and feed of less than 3 million tons.

We have carried on many types of market development activities in Japan. The nutrition theme was emphasized in cooperation with the Japanese Government, Ministry of Health and Welfare, because they agreed that wheat foods improved nutrition and added a needed variety to the meals of their people who had historically eaten rice usually three times a day. Posters and pamphlets were prepared and distributed through the prefectural health centers.

The wheat food message of lower cost and better nutrition was brought to the housewife's door through twelve kitchen demonstration buses. The bus program has now been turned over entirely to the Japanese cooperator, and it is estimated that by the end of this year there will be over 60 buses in operation. An estimated 4 million housewives were reached by these buses traveling over 400,000 miles during the first four years of the project.

The children in any country soon become the customers and the buyers. One of the most popular projects we have had to date has been the expansion of the school lunch program. There are about 19 million pupils in school in Japan. Eight million of them were receiving the benefits of a noon lunch when this project started in 1957. This number had increased to 9,697,000 by May 1, 1961. The percentage of children in school lunch in the primary schools increased from 56.4 percent in 1957 to 70 percent in 1961. This project, in cooperation with the Ministry of Education and the National School Lunch Association, has provided lunches for an additional 1.5 million school children during the first four-year period.

This approach to developing wheat markets can best be termed as long range. However, it is a positive approach. We have learned that food habits are one of the most tenacious of all cultural traits. The time to change or develop them is during childhood. Even in rock-ribbed rural areas where rice traditionally has been the staple, wheat foods are making definite inroads.

We are now concentrating our market promotion on those food products that use primarily U.S. wheat flour. These include confectionery products, noodles, biscuits

and crackers, and wheat foods new to the Japanese, such as hot-cakes, waffles and western-style cakes. Activities are underway now to introduce United States hard wheat flours to the bread bakers.

Based on the theory that you increase consumption by improving quality, we have sponsored a bakers training school in Tokyo and bakers clinics throughout Japan's 46 prefectures. Four-hundred fifty bakers have graduated from this school, and they have held workshops throughout the country attended by more than 20,000 other bakers.

These are examples of the market development techniques we have used in Japan. More than 1-1/2 million dollars have been spent on this program since 1956 in cooperation with the Foreign Agricultural Service, Japanese industry groups, and United States wheat growers. The first objective to expand the total market and increase per capita consumption has been largely satisfied; in spite of five bumper rice crops, wheat flour consumption during this period has increased roughly 10 percent. Pre-war consumption of wheat foods was 30 pounds and rice about 300 pounds. Today rice has decreased to less than 264 pounds, and wheat has increased to about 78 pounds overall--and to 96 pounds in the cities.

Our present objective is to increase the United States' share of the Japanese wheat market. We are confident that substantial gains will be made in this direction this year. Last year the United States shipped Japan 847,000 metric tons of wheat. This year we expect to increase that amount to a minimum of 1,000,000 tons and to a maximum of 1,250,000 tons. There isn't time now to go into the background of all the reasons why this will happen. We are satisfied, however, that our market development program has been one of the most significant factors.

The Philippines. The Philippines is our other major dollar market in the Asian area. This country is completing the transition from a flour importing nation to a wheat importer through the development of the national flour milling industry. The first mill began operations in 1958. By mid-summer of 1962, mills will be grinding, with a total capacity in excess of domestic needs.

Last year the United States was supplying over 85 percent of this new wheat market. It would be unrealistic or wishful thinking to expect to maintain that dominating position on a permanent basis. This market is very brand conscious, and their uses for bread flour require an unusually high protein, high gluten wheat which has been supplied primarily by dark northern spring from the United States at premium prices. As additional flour mills have come into the market and competition has become more severe, they have started importing lower quality, less expensive wheat to blend with DNS as one means of reducing their cost.

Spring wheat of 16 percent protein is in short supply not only in the United States but in the world. For this reason, it is probable there will be some substitution during the next year or two of lower protein, less expensive wheat. At present the United States has about 75 percent of this market. Forty-five percent is DNS and 20 percent is western white. Canadian spring makes up the difference. Unless the present price spread between DNS and Canadian spring can be narrowed, it is probable that an additional 10 percent of this market will be gained by Canada during the coming year. The unusually high price of high protein DNS and its unavailability off the West Coast are problems that will require the best effort of the wheat growers working in cooperation with the U.S. Department of Agriculture.

There are opportunities for expanding the total market for wheat foods in the Philippines. The per capita consumption of wheat foods is low--only about 22 pounds per year. The population is increasing and will soon reach 25 million. Fiddling with figures again, a 10-pound per capita increase per year would require an additional 125,000 metric tons of flour milled from 5-1/2 million bushels of wheat.

Within another year, eight flour mills are expected to be in operation. They will require about 400,000 metric tons of wheat to operate at rated capacity. The market presently will absorb closer to 300,000 metric tons of wheat, so the pressure will be on the new milling industry to cooperate in the expansion of the total market for wheat foods.

This is a new market development area for us, and projects are just now being drafted in cooperation with the milling industry and other groups to expand the total market. Our major objective here, however, initially will be to maintain the United States' share of the market at as high a level as is possible.

Conclusion. This completes my review of our market development opportunities for wheat in four of the major countries and several minor countries in the Asian area. There are other important markets in this area that I have not mentioned, including Korea and Formosa. Opportunities exist in almost every country in this region.

In the two non-dollar markets, India and Pakistan, wheat imports may vary by 75 million bushels a year depending on their local crop conditions. We are working for effective utilization of these huge inshipments--plus expanded consumption in the rice eating areas.

We have the opportunity to double the exports of United States wheat to the major dollar markets, Japan, the Philippines and smaller countries in the Burma area, during the next five years. Exports to this region could increase from the present level of 40 million to 80 million bushels of wheat per year. It is in this key area of dollar markets that we envision the greatest opportunities and anticipate the most severe competition for future sales.

ACTIVATING MARKETS FOR UNITED STATES WHEAT IN LATIN AMERICA

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The important role that wheat can play in Latin American countries is being rapidly brought into focus. The direction that the movement of wheat is taking and will continue to take in these vast areas will depend to a great deal on our international relations, the extent of our market development programs, the availability of supplies and the use made of the great many tools available under the very flexible selling and disposal programs of the United States government.

The Latin American area, which includes Mexico, Central America, the Caribbean and South America, has about one-sixth of the world's land surface. Its population is growing faster than any other major area in the world. Although farm production in these areas has risen faster than the rate of population growth, it is expected that food availability and consumption will continue to remain below nutritional standards for some time. The areas of these deficiencies have been so great that only the failure to take advantage of the many U. S. programs for obtaining food can hold back the movement of additional wheat.

During the course of my discussion I will cover the following:

1. Wheat consumption by these countries and the areas that show the most promise for the increased use of U. S. wheat.

2. The many program possibilities we have, old and new, with which to build this additional consumption.

3. The costs of holding surplus wheat and the justification for making every effort possible to build additional markets in these areas while the present situation exists.

4. The competitive position of U. S. wheat, now and in the future in these areas.

5. The possible direction of Congress after surpluses are disposed of as related to continued sales in these Latin American areas.

6. A working example of just what can be done and is being done to develop one of these great market potentials--Brazil.

7. The role of the cooperators and government in the promotion of these sales in Latin American countries.

8. The Billion Bushel export possibilities in the foreseeable future and the important role Latin American countries can play in attaining that goal.

A PRODUCT CONCEPT APPROACH TO EFFECTIVE MARKETING AND DISTRIBUTION PROGRAMS FOR U. S. WHEAT IN AFRICA

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(This report was presented by Walter H. Harte.)

DCA Food Industries, formerly known as Doughnut Corporation of America, today is engaged in the manufacturing, processing and marketing of food products and machinery in the United States and overseas. In spite of our diversification activities over the past several years, which has brought about our corporate name change, the great majority of our activity is still centered around the processing of wheat and wheat flour into intermediate and end products and the manufacture and sale of machinery to produce products based on wheat flour. On the other hand, although we own and operate two of our own flour mills in the United States we are primarily buyers of wheat and flour rather than sellers and therefore have never undertaken studies of overseas markets for these commodities as such.

Fortunately, Foreign Agricultural Service of the U. S. Department of Agriculture and its cooperators have funds and personnel available for this purpose and we certainly wouldn't want to duplicate any of their activities. Also we were fortunate enough to receive a fine background on the African situation from Mr. Jones during yesterday's discussion. Therefore, in view of the coverage already given the subject of the use of wheat in Africa, I don't feel particularly qualified to delve into the ecology of the African continent, rehash published trade statistics, analyze the treaties and agreements now under discussion with many of the African governments, or to comment on the possibilities and pitfalls of United States government aid programs slated for Africa. Accordingly, I would rather limit my talk to a discussion of the more effective utilization of United States wheat and wheat flour--as well as other abundant United States commodities--as instruments of foreign policy in the protein-deficient areas of West Africa. We feel that such activity should also result in the long-range development of new self-supported commercial markets for these commodities at some future time when government aid is diminished.

Last year our company submitted to Congressman McGovern's Food For Peace group an unsolicited report outlining our analysis and approach to this problem and then, somewhat naively, spelled out a specific program which we considered capable of immediate implementation. Today, after almost one year of alteration and amendment based on our gradually increasing awareness of the obstacles involved, I would like to lay before this group, first, a description of our so-called "product concept" approach--which actually hasn't changed much--and, second, to outline a pilot project which we developed for Africa and hope to implement specifically in Nigeria. This plan, I might add, has been modified considerably during this past year.

The "product concept" approach. All of us concerned with the international aspects of the food industry are quite naturally following the problems confronting our government's overseas food programs with a great deal of interest. It occurred to us that we might be able to help contribute to the solution of some of these problems. Among the most abundant U. S. agricultural commodities are, of course, wheat and wheat flour. Unfortunately, various efforts to promote their use abroad have been handicapped by several factors, the most important of which include the necessity for processing them into acceptable products and the fact that the end products have nutritional shortcomings. Various attempts to overcome these difficulties have been and still are hindered by government regulations limiting their use pattern. These problems are discussed as follows:

Processing requirements. As wheat and flour cannot be consumed directly, they must be somehow converted into products which are not only acceptable to local tastes, but for which a sizable demand can be created. This processing requirement is a serious handicap to mass product acceptance, whether the actual processing is carried out by a centralized factory producing an end product for local distribution, or by the consumer himself at the point of consumption. In the first instance, neither private nor governmental groups are anxious to invest in the required buildings and equipment to produce end products for which the market potential may be unknown, and which would be dependent for raw materials on government aid programs from the United States. As far as home processing is concerned, the promotional and educational problems involved in introducing a finished food product are challenging enough in themselves in a literate country. The chances for success of such programs are drastically reduced when consumers must also be taught and "sold" new methods of processing or preparing the foods.

Nutritional shortcomings. The nutritional problems of many of the key foreign aid target areas, such as the Far East, India and West Africa, involve protein deficiency. Most end products made from wheat flour, although containing certain amounts of protein (gluten) from the wheat itself, ordinarily are inadequate from both a quantitative and qualitative point of view. In short, these products cannot be considered to offer a nutritional balance which would maximize their effectiveness in large-scale feeding programs. This is especially true of areas where kwashiorkor is prevalent.

Government regulations. Although United States government regulations affecting the overseas uses of subsidized wheat and flour are far too numerous and complicated for definite analysis in a report of this type, it should be noted that the regulations forbidding the processing of donated wheat flour prior to shipment from the United States preclude any significant nutritional enrichment or conversion to a more ready-to-eat, convenient, end product form. Rather than attempt to change these regulations, we set out to develop a program which would overcome the processing difficulties and nutritional shortcomings, but still remain more or less within the framework of existing policies. The basis for the development of this particular program is the high-protein doughnut as a product concept.

The high-protein doughnut. On the premise that successful feeding programs utilizing the most abundant U. S. commodities must be based on the distribution of acceptable products rather than raw materials, we have applied the following criteria to the doughnut concept as an ideal ration for overseas feeding programs:

1. Nutritionally speaking, such a product should meet the minimum requirements of a balanced food in providing protein, fat, carbohydrates, and vitamins.
2. It should be produced in a single ration size which can be eaten anywhere without utensils, and without the necessity for supplementary flavorings or companion products.
3. It should have flexibility in formulation for conformity to local tastes and taboos, as well as for addition of special nutritives.
4. As a product, it should have distinctive physical features which can be exploited by promotional activities to popularize the product.
5. Its major ingredients, by bulk and dollar value, should be produced in abundance in the U. S.
6. The end product should be inexpensive, not only from the point of view of its original procurement for subsidized feeding programs, but also from the point of view of eventual local production from materials which can be obtained locally or purchased commercially at world market prices.

Although most existing commercial varieties of doughnuts meet many of the above criteria, DCA's Central Research Laboratory has been engaged for some time in the development of a special high-protein formula specifically for use in overseas areas where protein deficiencies are prevalent.

Nutritional features. The properties of the DCA high-protein doughnut, which we propose to use in a school feeding program for overseas are: moisture 24.9 percent, protein (Nx5.7) 18.02 percent (dry), protein (Nx5.7) 13.50 percent (as-is basis). In addition to merely raising the protein level, it was also necessary to create a balanced protein content, including the addition of lysine (from soya protein) which is not significantly present in wheat gluten. The following tabulation shows the quality of the protein fraction, calculated as follows:

$$\frac{\text{mg. lysine}}{N} = \frac{1041.2}{3.191} = 326 = 3.25$$

	P.E.R.	Biological value
Whole egg	3.80	90
High-protein doughnut (protein fraction)	3.25	82
Beef powder	3.20	80
Casein	2.00	62
Peanut flour	1.70	56
Wheat gluten	1.00	47

Use of abundant U. S. food products. Another significant feature of the doughnut is that its basic raw materials are those produced in abundance in the United States. The ingredients used in the DCA high-protein doughnut are: wheat flour, soya flour, dried milk solids, eggs (whole, dried, and yolk), vegetable oil (including soya oil), and sugar (usually available cheaper in overseas areas than in the U. S.).

In addition to the supplementary nutritional additives, the only additional ingredients required are leavening agents and flavors (which constitute less than 2% of the end product by weight). Often the flavor can be obtained within the consuming country to conform to local tastes.

Low cost of product. Based upon our preliminary cost calculations for several of the "developing countries," even in cases where materials costs are higher than in the United States, it is usually possible to sell such doughnuts at a good profit for less than the local currency equivalent of 4 cents apiece. This is without subsidy of any kind. How U. S. government assistance under the Food For Peace Program might enable voluntary agencies to distribute these high-protein doughnuts at a cost of less than one cent apiece will be spelled out subsequently.

Details of a proposed church world service child feeding program for overseas. Based upon our knowledge of the protein deficiency which is prevalent among the children of Nigeria, as well as other areas of sub-Sahara Africa, the experience we have gained through the acceptance of our product by local nationals through the operations of our affiliate company, Nigerian Donut Company, Ltd. (Nidoco), we have proposed that DCA, Church World Service, and Nidoco cooperate to establish a pilot child feeding program in the area of Lagos, based upon the distribution of the DCA high-protein doughnut on a year-round basis. It is hoped that this program may establish a success pattern for larger scale projects elsewhere in Africa and other protein deficient areas.

Operation and organization of the proposed pilot program. Essentially, Nidoco would agree to deliver sufficient numbers of high-protein doughnuts (described previously) to designated distribution points--starting in the greater Lagos area--to feed 17,500 children two doughnuts per day per child five days per week during the entire school term--or on a year-round basis if alternative distribution points can be established. These doughnuts would provide about 10 grams of total protein per child per day.

According to our plan, payment for these doughnuts would be made by Church World Service entirely in the form of wheat from the Christian Rural Overseas Program (CROP), with no expenditure of CWS cash involved at any point. As CROP wheat is not technically U. S. government property, it can be used to pay for processing and distribution costs, whereas U. S. Department of Agriculture wheat under P. L. 480 cannot.

Nidoco, of course, would make the investment required for the purchase of additional doughnut manufacturing equipment to meet the volume which may be agreed upon. The proposed operation would work as follows:

1. DCA will manufacture its high protein doughnut mix at its factory near Baltimore, Maryland, and deliver same, export packed, to Church World Service F.A.S. Baltimore.
2. CWS will arrange for transportation of the mix from Baltimore to Lagos--freight costs possibly can be paid by AID.
3. CWS will arrange for gifts of USDA (Commodity Credit Corporation) stocks of hydrogenated soybean oil--if possible--for use as frying fat and also arrange for its shipment to Lagos. If this material is not available through CCC we shall approach the Soy Bean Council of America for their possible assistance.
4. CWS will deliver the DCA high-protein doughnut mix, plus the frying fat, to Nidoco, in Lagos. The Nigerian government should be asked to permit the entry of these materials under Custom Bond on a duty-free basis as long as the equivalent in end product is distributed under the school feeding program.
5. Nidoco will receive the bonded mix and frying fat and will process these ingredients into high protein doughnuts. Until such time as CWS assigns a permanent, full-time staff to Nigeria, it is hoped that AID can assist in making arrangements with the Nigerian government for the delivery of the doughnuts to designated distribution centers in the Lagos area. The present CWS representative would supervise and oversee their interests in the operation and act as liaison with AID and the Nigerian government. If further administrative controls were desired, such functions might be assumed by appropriate AID officials.
6. DCA would receive payment in CROP wheat.

Total costs. Based upon our estimates for the procedure outlined above, a program to feed 17,500 children two high-protein doughnuts per day, 300 days a year (900,000 dozen per year) would include payment of approximately 29 carloads of CROP wheat. Each doughnut would cost less than nine tenths of a cent in CROP wheat, or put another way, each bushel of CROP wheat--two dollars a bushel-- would buy approximately 225 high-protein doughnuts, delivered in Nigeria. Larger scale programs, of course, would result in lower unit costs and therefore in proportionately lower total outlays.

Discussion. The doughnut composition usually contains about 25 percent of fat. The carbohydrate content can be approximated by difference as about 36-37 percent. Introduction of this doughnut production operation is being considered for other African areas if the present trial proves satisfactory. Comment was made that the Nigerian children were pretty lucky to be receiving their protein aid program through doughnuts.

WHEAT CHARACTERISTICS REQUIRED FOR LEAVENED PRODUCTS IN EUROPEAN AND ASIAN MARKETS

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Any study of the "Role of Wheat in the World's Food Supply" must deal with the dynamics of a rapidly changing world economy as well as changing technology and changing diet. It must also deal with the vagaries and forces of nature and the skills of man as they affect the intrinsic qualities of wheat wherever it is grown. These same forces establish the wide differences in milling and baking properties of wheat. I will attempt to show how these interrelationships affect the United States in its world position as an exporter of bread wheat to Asia and Europe.

In Asia there are two distinct markets - the Philippines and Japan. In the Philippines, which are entirely dependent on imports of flour or wheat, we meet the greatest requirements in world markets for very strong, long-fermentation-tolerance spring wheat flour. This is true because of long acquaintance with strong flours and because of tropical conditions and lack of temperature controls in the bakeries. Though per capita consumption is low, it is widespread. With some 80 percent of the wheat going into fermentation products, the baker desires the traditional high protein flour which gives him a high yield of his pan de sol breakfast rolls. The U. S. market which has been decreasing in the Philippines, provides hard red spring wheat of 14-17 percent protein to meet the requirements. As Philippine technology improves, there will be a probable increase in the present small amount of imported hard red winter wheat. The Philippine market now wants the strongest flour possible.

In Japan the situation is different. About a third of her present needs are locally produced, but about 90 percent of her bread flour is milled from imported wheat. Indigenous semi-soft low-protein wheat goes to the noodle and confectionery industries. The Japanese baker, with modern plants and technology, is beginning now to become accustomed to the higher oxidation and amylase requirements of hard winter wheat. He has been used to spring wheats, and in his changing technology judges imported wheats against Canadian Manitoba. The unusual usage of a small fraction (perhaps 10 percent) of a fancy patent flour is a major economic factor in Japanese wheat milling, yields of which can make important profit differences. This puts a premium on low ash and good color--conditions which many United States wheats cannot well meet. The previously rigid requirements of the Japanese market are becoming more flexible as a result of political and economic forces and market development activities. The change favors increased use of varying qualities of hard winter wheat if it is clean and can be competitively priced at West Coast ports.

We next turn 180 degrees and consider the European market, one characterized by the great variety of breads produced. Western Europe is over 90 percent self-sufficient in wheat production, but quality is lacking. Requirements vary. Austria and Switzerland prefer strong spring wheat for blending purposes. Belgium requires a very strong wheat as their own is very weak. Dutch millers are highly price-conscious and buy poorer qualities. In general, European millers buy spring wheat to get strength and hard winter wheats as fillers on a price basis. A further complicating factor is the prohibition by law of our usual bleaching and maturing agents, which favors spring wheat. These combined requirements call for a medium strong to strong wheat that will carry up to 75 percent of a weak wheat in the blend, have low oxidation requirements, and give a good flour yield with low ash.

In the markets discussed, which account for over half of present dollar sales of U. S. wheat, bread quality requirements are judged against Canadian Manitoba. Our competitive position, good in Japan but poor in the Philippines and Western Europe, would be improved by stronger varieties of wheat with higher protein levels, lower ash contents and oxidation requirements, and less non-millable content.

OBSERVATIONS OF WHEAT NEEDS IN THE EUROPEAN COMMON MARKET

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The rapid development of the European Common Market is the most significant change affecting the European Community and its relationship to other countries in the last century. The core of this development is the European Economic Community, consisting of six countries (West Germany, Netherlands, Belgium, Luxembourg, France, and Italy). These countries cover an area one-seventh the size of the United States, with a total population almost as large as the U. S., and with a slightly larger labor force. It is predicted that in a relatively short time they will be joined by the Outer Seven (United Kingdom, Denmark, Norway, Sweden, Portugal, Austria, and Switzerland). Great Britain has set January 1963 as her target date for joining the EEC. What effect will the EEC have on U. S. wheat exports? Can utilization research contribute to the increased use of U. S. wheat in the Common Market countries?

As a reference point for evaluating how the Common Market may affect U. S. wheat exports, let's begin by examining where our wheat goes and what portion of it is exported to Western Europe. Figure 1 shows the 1960-61 utilization pattern for U. S. wheat. Note that 52 percent of the total disappearance of our wheat was exported and the remaining 48 percent was used at home. Of the total exported, approxi-

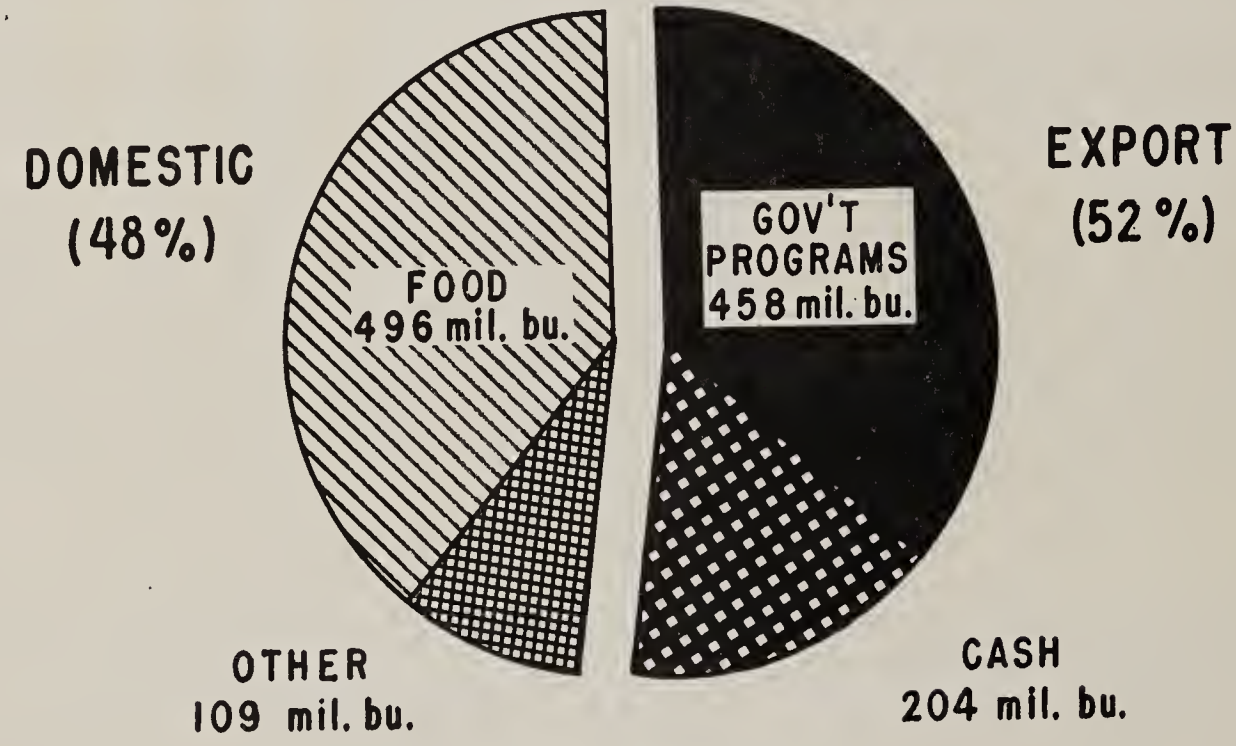


Figure 1. Utilization pattern for United States wheat, 1960-61.

mately 69 percent was sold under Government programs, and 31 percent was cash sales. Is this typical of total wheat disappearance in recent years?

Table 1 shows that only in the last 2 years have exports exceeded domestic disappearance. Exports account for a significant part of the total market for U. S. wheat. If these markets are to be maintained or expanded, increased emphasis must be given to supplying wheat that meets the particular needs of each importing country. We must tailor-make our wheat products for specific uses in specific markets.

Table 1. Wheat disappearance, United States, 1955-61.

Year beginning July	Disappearance		
	Total	Domestic	Exports
	Million bushels		
1955	949.8	603.5	346.3
1956	1,137.8	588.3	549.5
1957	994.4	591.5	402.9
1958	1,051.1	607.8	443.3
1959	1,110.1	599.9	510.2
1960 1/	1,266.8	604.9	661.9
1961 2/	1,265.0	590.0	675.0

1/ Preliminary.
2/ Partly estimated. Source: Wheat Situation, Economic Research, U. S. Department of Agriculture, March 2, 1962.

Figure 2 shows that the increase in production efficiency of the U. S. wheat farmers has exceeded the development of new markets. The carryover of wheat has been increasing in recent years despite an increase in exports and the maintenance of domestic consumption.

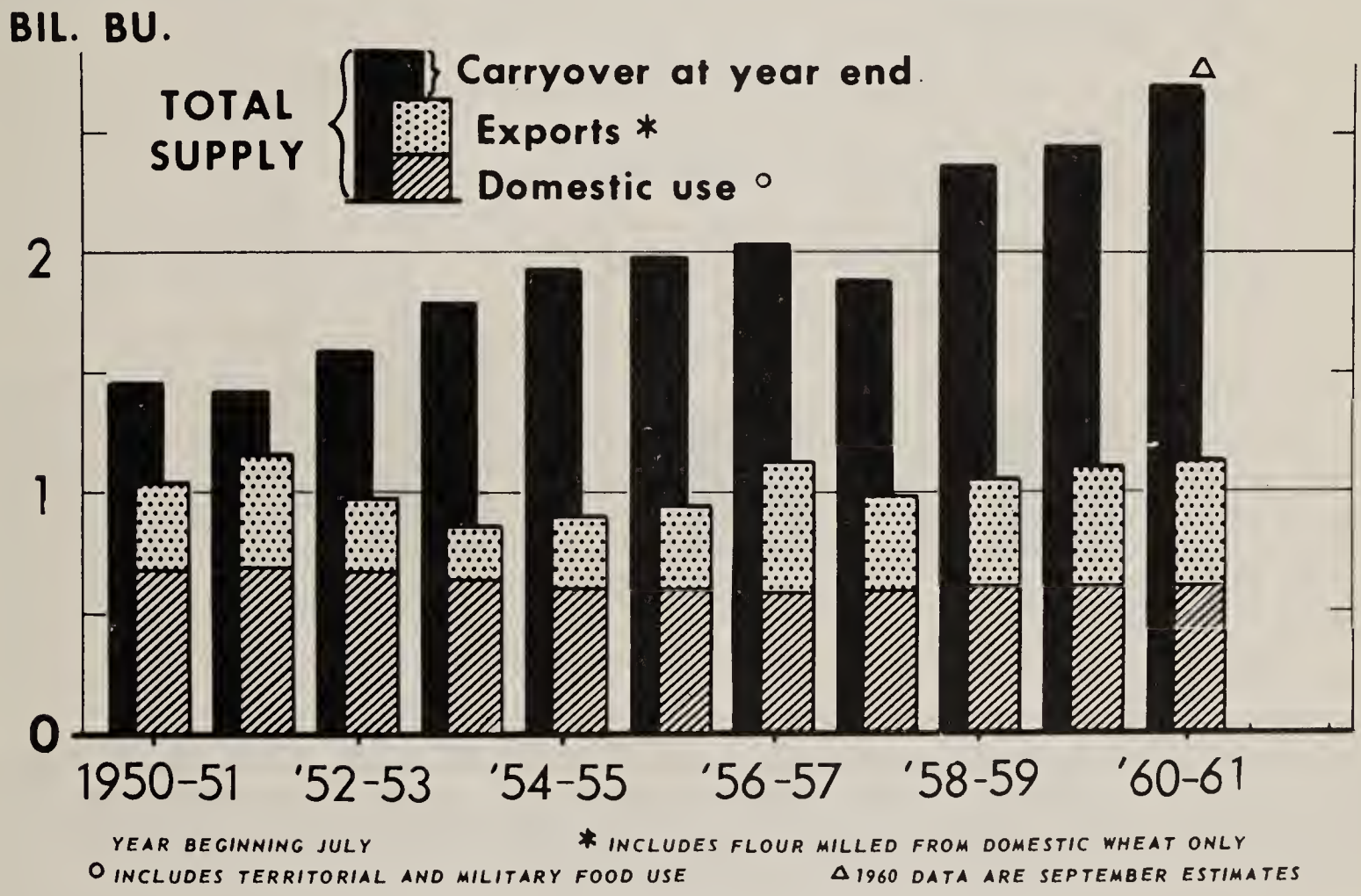


Figure 2. Wheat supply and distribution. . .

Against this background we will examine wheat and wheat flour exports to the European Common Market. Table 2 shows exports by area of destination. Note that about 48 percent of our total cash sales of wheat and wheat flour went to Western Europe in 1960-61. Western Europe accounted for only 10 percent of the sales under Government programs. This is the equivalent of about 97 million bushels sold for cash and 46 million bushels under programs. Together, cash and program sales to Western Europe accounted for about 21 percent of our total wheat and flour exports in 1960-61.

Table 2. Wheat and flour exports, United States, 1958-61.

Destination	1958-59		1959-60		1960-61	
	Cash	Govt.	Cash	Govt.	Cash	Govt.
	Percent					
West Europe	36.5	11.0	32.6	5.5	47.8	10.0
Asia	34.7	58.8	35.2	56.3	25.7	54.4
N & C America, Carib.	13.4	0.4	14.9	0.6	10.0	0.3
South America	10.0	8.5	11.1	13.1	9.5	10.0
Africa	5.4	6.8	5.5	12.6	6.9	12.3
East Europe	0.1	14.5	0.5	10.4	----	12.1
Oceania	0.9	----	1.5	----	1.2	----
Other (unspecified)	0.9	----	0.2	1.5	----	0.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: U. S. Grain Exports Under Government Programs, 1960-61, FAS-M 127 February 1962, Foreign Agricultural Service, U. S. Department of Agriculture, Washington, D. C., and data for previous years supplied by FAS Grain and Feed Division.

Figure 3 shows exports in terms of metric tons for cash and Government sales.

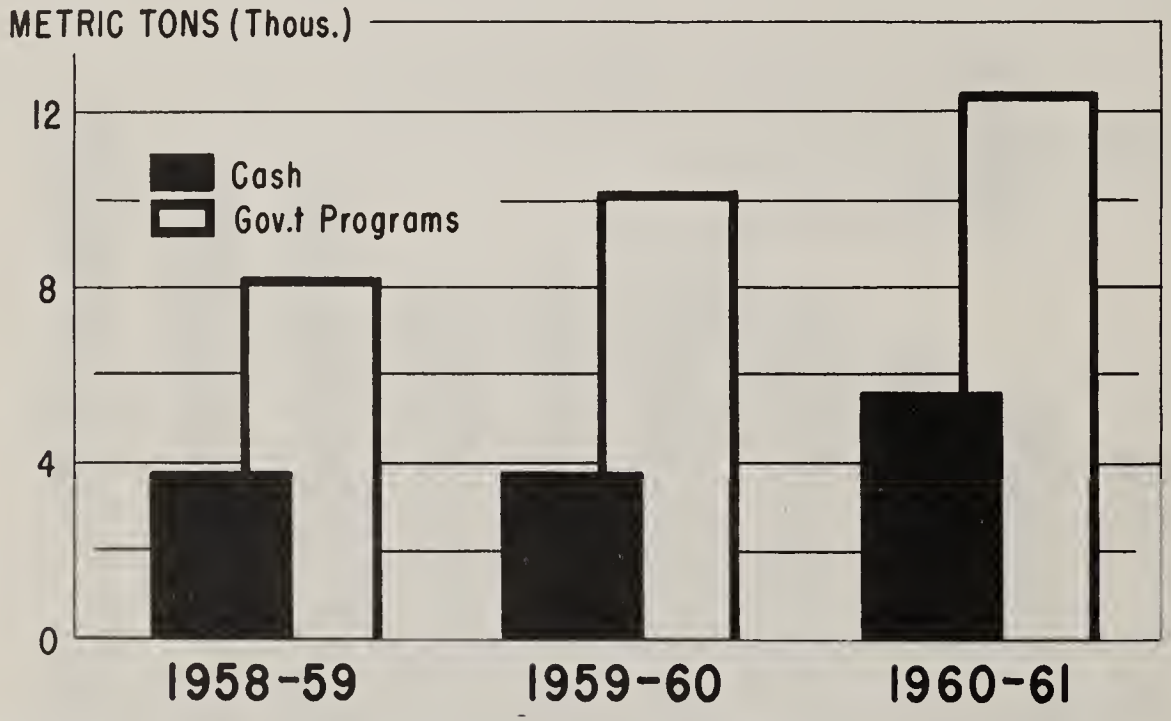


Figure 3. Total exports of United States wheat and flour, 1958-61

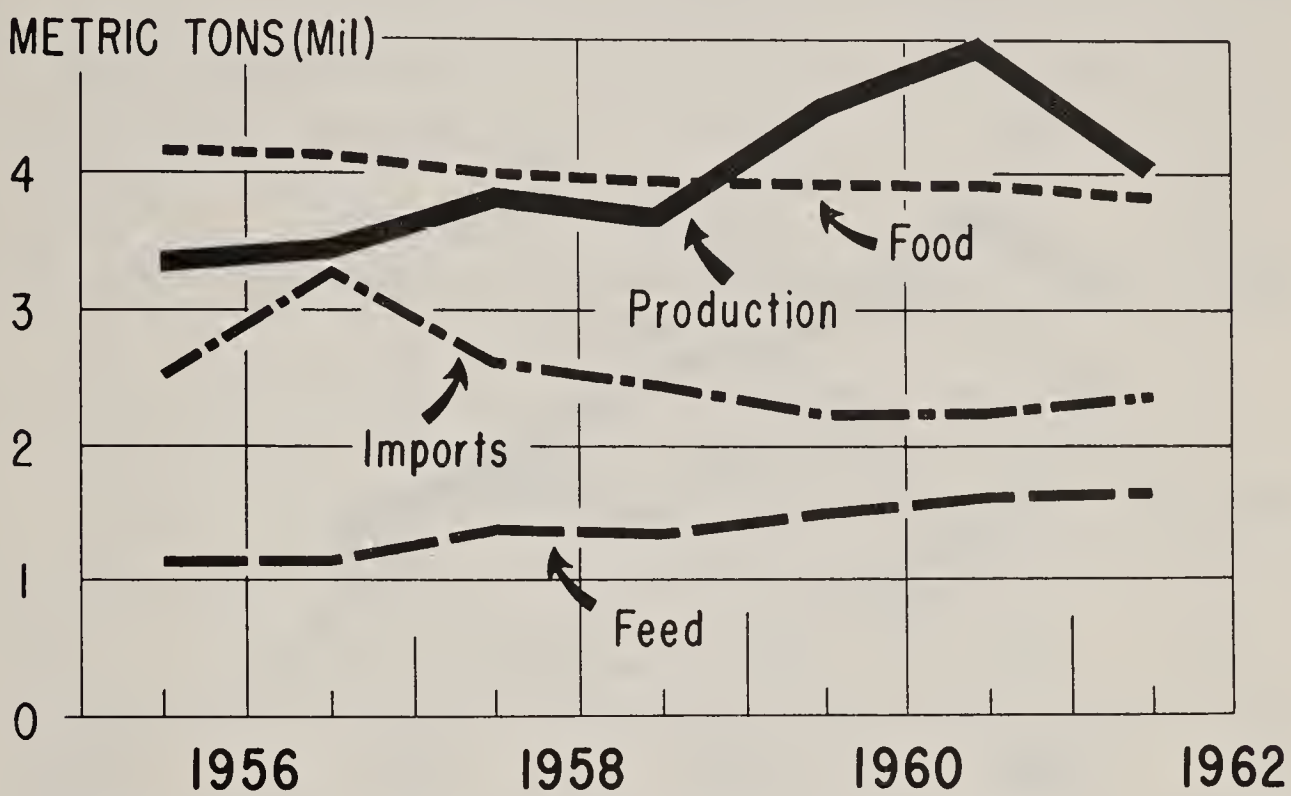
Sales for cash and under Government programs increased significantly in 1960-61. The increase in exports during the last 3 years suggests an optimistic outlook for the future; however, the outlook is not optimistic for future exports to the Common Market countries or to Western Europe. Let's see why.

The Common Market countries produce nearly all soft wheat varieties. Their baking strength is poor. Except for France, all the countries import stronger wheats to blend with the local wheats. The Common Market countries as a group are capable of producing practically all of their wheat needs in terms of bushels, but not in terms of quality. A good illustration of how this may affect U. S. wheat exports can be found in West Germany.

In West Germany, quality hard wheats are imported to satisfy 25 percent of the food utilization requirements. This occurs even though West Germany produces more wheat, in bushels, than they utilize for human consumption. During February 1962,

the German millers were paying $3.16 per bushel for local wheat delivered at the mill; $3.20 for imported U. S. hard red winter wheat; and $3.27 for Canadian hard red spring wheats c.i.f. In order to obtain the properties essential to making desirable breads, the German millers and bakers were paying a premium for imported wheats over domestic wheats.

Figure 4 shows that domestic production of wheat in Germany has been increasing until it now exceeds domestic food consumption. Total imports have decreased as



INCLUDES WEST BERLIN; SINCE 1959-60 INCLUDES SAAR

Figure 4. Production, importation, and utilization of wheat in West Germany, 1956-62.

domestic production increased, but not as much. The use of wheat for feed has increased. This is the result of increased production of domestic wheat which has poor bread-baking strength. Note also that the total wheat consumed for food has been declining. Apparently the rise in per capita incomes in Germany is having the same effect in reducing per capita wheat consumption as it has had in the United States. What is of even greater concern to the U. S. wheat grower is the decline in the U. S. share of German wheat imports.

Figure 5 shows that the U. S. share of German wheat imports has dropped from around 40 percent in 1955, 1956, and 1957 to less than 17 percent by 1960-61. During this same period the imports from Canada increased from 31 to 54 percent. The higher the proportion of local wheats required to be used, the greater will be the incentive to demand wheats of higher protein level and strength. This situation can be pushed to the point where practically all imports are Canadian wheats. This has already happened in Belgium.

In Belgium, wheat yields are extremely high; protein level and strength are unusually low; and only 30 percent imports are allowed. (There is an exception which permits imported wheats to reach about 35 percent of domestic use.) According to Dr. Maes, Minister of Economic Affairs, the millers and bakers would prefer to reverse the import situation--two-third imported (one-third hard red spring and one-third hard red winter) and one-third domestic-- in order to bake more desirable food products. (This was the original proportion before the government regulated imports of wheat.) Since the average protein level of Belgian wheat runs between 7.2 to 7.4 percent and

about 90 percent of their baked goods are types of bread, it is apparent why the present import regulation is an unhappy one for both millers and bakers. As a result of the high proportion of low-protein domestic wheats required by law in Belgium, the trade attempts to offset this handicap by importing Canadian wheats (90 to 95 percent of their imports, according to Dr. Maes) which they consider to be of higher protein level and strength than U. S. wheats. This illustrates what could happen in other European countries such as The Netherlands, Great Britain, and Germany if the EEC (through political decision) forces a higher usage of domestic soft wheat, including French wheat.

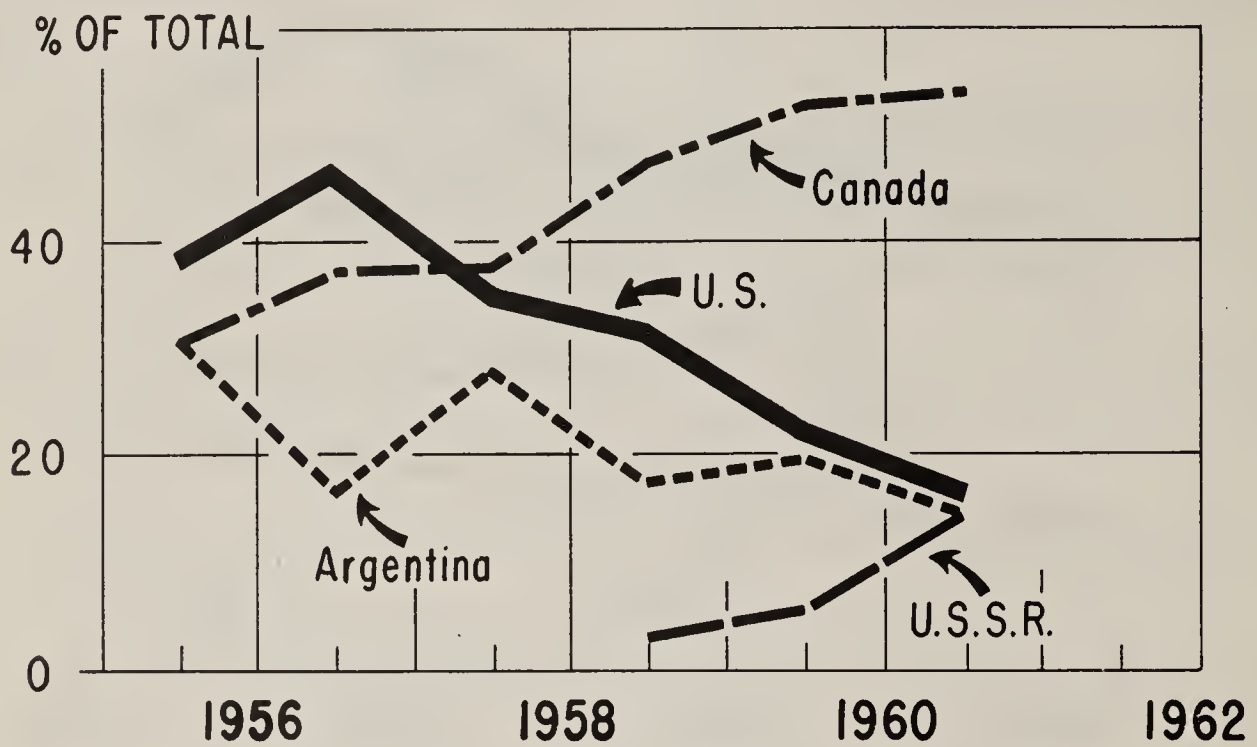


Figure 5. Sources of wheat imported into West Germany, 1956-62.

If more soft wheats from France, Belgium, West Germany, and The Netherlands should be forced upon the millers and bakers in Great Britain, The Netherlands, and Germany, only Canadian wheats are likely to be imported because of the increased demand for wheats with higher protein level and strength. Such a result will ensue if political decisions override wheat property needs based on utilization requirements. Over one-third of U. S. dollar sales of wheat goes to Western Europe; the loss of this market would be a serious blow to the U. S. wheat farmer.

Canadian wheat provides the yardstick for high quality so far as imports into the Common Market countries are concerned. This yardstick has been clearly stated in a recent study, "Germany's Need for Quality Wheats," made by Agri Research, Inc., for Great Plains Wheat, Inc. Table 3 shows the relationship between German, Canadian, and U. S. wheats with respect to protein level, moisture content, and sedimentation value. These data were derived from laboratory analyses of 69 samples of wheat

Table 3. Wheat

Item	German	Canadian	U. S.[1/]
Protein percent	9.6	13.3	12.0
Moisture percent	14.0	13.6	12.5
Fat acidity	25.69	22.14	26.2
Sedimentation value	16.8	55.3	34.6
Pelshenke index	21.0	40.0	30.0

1/ Two samples.

collected at German flour mills in the fall of 1961. There were only 2 U. S. samples and both were hard red winter wheats. There were 33 samples of German wheat and 16 Canadian. Note that the U. S. wheat samples fell about halfway between the German wheat and the Canadian. Table 4 shows the flour comparisons for maltose value and farinograph characteristics.

Table 4. Flour

Item	German	Canadian	U. S. 1/
Maltose value	209.0	160.6	129.5
Farinograph characteristics			
Peak time (min.)	1.11	7.36	5.87
Mixing tolerance (min.)	2.11	9.87	8.25
Absorption	55.3	63.2	60.7
Valorimeter	35.3	68.8	61.5
MTI	88.8	40.0	35.0

1/ Two samples.

Table 5 shows the bread comparisons for loaf volume and bread score.

Table 5. Bread

Item	German	Canadian	U. S. 1/
Loaf volume (cc)			
AACC	592	816	740
Remix	630	848	730
Bread score			
AACC	74.8	91.0	83.5
Remix	76.2	92.4	84.0

1/ Two samples.

Blending capacity for bread-baking purposes is considered to be the most important criterion for imported wheats. Unfortunately, blending capacity has not been studied to an extent necessary to provide a description of its most important details. At present, roughly 1 bushel of Canadian wheat or high-quality wheat is blended with each 3 bushels of local German wheat. Would air classification of hard red winter wheat provide a high-protein fraction which could enable the Germans to use 5 or 6 pounds of their local wheats for each pound of the imported high protein fraction? Are there any varieties of U. S. hard red winter wheats which would make such a practice technically feasible? Secondly, if it is technically feasible to do this, would it be economically feasible? What contribution can utilization research make to improving the competitive position of U. S. wheat in the Western European markets? Recent studies have indicated that additional soft wheat can be grown in Western Europe. These studies indicate that in terms of quantity enough bushels can be produced to make this area self-sufficient, but not in terms of wheat quality. It is evident that as more local wheats are consumed, the demand for higher quality imports will increase. Recent studies show that U. S. wheats are not competitive with Canadian wheats in terms of high quality, uniformity, and cleanliness.

Utilization research can make a contribution to the competitive position of U. S. wheat by answering the following questions:

1. What can be done in the way of utilization research to:
   a. Devise methods for developing strong bread doughs from U. S. wheat without the necessity of additives?
   b. Develop methods of oxidizing U. S. hard wheat flour that are acceptable to the Common Market countries now prohibiting U. S. procedures?

c. Demonstrate that certain oxidizing agents used within limits are not harmful in wheat breads, and thus gain acceptance of trade practices making U. S. wheats more competivive?

2. Can air classification of U. S. hard wheat flour supply a high-strength, high-protein fraction (to be competitive with high-strength Canadian wheat) which would be advantageous for European millers and bakers to blend with their domestic soft-wheat flour?

Utilization research needs which are basic not only to the situation in Western Europe but to all other areas as well include the following: The fundamental need for utilization research on wheat is a thorough elucidation of the chemistry of leavening and the relationship of wheat composition to its baking behavior, including fundamental information on factors affecting blending capacity and possible complementary types of flour. Through such knowledge, means can be developed for making acceptable products from U. S. wheats in combination with European soft wheats. This would include a study of how wheat constituents affect flavor, texture, and nutritive value, and how to measure these quality factors. With this basic information in hand, answers can be formulated to such questions as:

a. Why does hard red spring wheat, having the same protein level as hard red winter wheat, yield flour with stronger bread-baking strength and blending strength?

b. What specific guides can utilization research provide plant breeders for developing new wheat varieties having improved properties?

Discussion. It was emphasized, that in the European Economic Community (the Common Market) the direction so far has been protectionist, with an attempt to use as much domestic product as possible. This probably will continue and may be pushed to the point where price may not be a controlling factor. We have been selling wheat in our continuing markets in Japan and the Philippines at a price disadvantage of about 30 cents a bushel over Canadian Manitoba No. 2.

Wheat of higher protein content than that indicated in the report has been produced in North Dakota, but the inventories do not show it in the export market.

INTRODUCTION TO SESSION ON EXPORT MARKETS FOR BULGUR

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It is indeed a pleasure to participate in a conference of this nature. The tremendous role that wheat now plays and will continue to play in meeting the world's need for food necessitates continued exploration and research. It also provides the forum for a free exchange of ideas, the fortifying of our hopes, the expressing of our fears, the making of our predictions and the setting of goals--all to the end result of an improved market for the additional consumption of wheat.

Aggressive research in the area of wheat utilization will continue to generate ideas and products which will eventually move more and more wheat into industrial and food gaps existing throughout the world. In meetings such as this, participants learn about new problems and gain understanding and new working relations that previously did not exist.

One thing that has been brought home strongly and clearly to me is the big job that has been done here in this Regional Laboratory on bulgur. Before we proceed to the panel session, I wish to summarize some of our thoughts on foreign marketing that apply not only to bulgur but to other programs and products. These concern some of our many future activities believed necessary.

The USDA has three very clear objectives in regard to sales: the extension of our efforts to regain our lost markets, the maintenance of our present markets, and the building of new markets. All these relate to the necessity for understanding and removing the obstacles which confront us. Our sales efforts must be geared to the individual markets, backed by the concerted efforts of market promotion specialists. USDA has the most flexible financing terms in the world, but there is a distinct need for clearer policy guidance. We must have a continuing improvement in the variety of export items and the improved conditions of our products at the point of delivery. We must maintain a pricing system which keeps us competitive on a day-to-day basis and must always protect ourselves against becoming residual suppliers. Our supplies should be made available through dependable suppliers of high integrity. More rapid government decisions could also help greatly. We must be constantly aware of the many trade barriers that exist and eliminate those which we can. We must also always be aware of the competition of Communist countries, which can break prices unreasonably at times to satisfy their own ends.

Improvements in our operations are always possible. A stepped-up future sales program could strengthen further our present daily sales. An improved world market intelligence would help greatly. The development of the right combination of prices and subsidies for the maximum benefit to U.S. exports is desirable. Our world food data are continually improving to keep us well aware of the great market potential for U.S. products.

Though I have pointed out some of our numerous problems, we must not forget that we have a good, firm foundation to work on and much progress is being made. This is proving very true in our bulgur program. While bulgur is an age-old form of wheat food, little thought was given to it until the Western Regional Research Laboratory here in Albany, in concert with interest shown by wheat grower associations and State wheat commissions, began experimentation in the early 1950's. Research led to the development of methods for reasonably economical volume production, and now wheat in the form of bulgur is moving in a greater volume as the people of a hungry world become acquainted with its many uses. The versatility of bulgur and ease of

preparation are assets that fill the bill perfectly for the introduction of a cereal protein food into the diets of people unaccustomed to eating wheat in any form. In the meantime, aggressive research, together with periodic discussion or conferences of this type, are valuable tools which we must not ignore, but rather encourage to the fullest extent possible.

EXPORT MARKETS FOR BULGUR

Clancy Jean
Western Wheat Associates, Inc., Washington, D. C.

In the mid-twentieth century, we are witnessing a rebirth of what is perhaps man's oldest form of wheat food--bulgor, bulgar, bulgur, bulghour, etc. In the Fertile Crescent where it originated milleniums ago, bulgur is still prepared and eaten. But, its reincarnation in the U.S. is taking bulgur to much of the world where it is being seen and eaten for the first time. As such, bulgur is a cultural import--and whether it be food, fashion, or fantasy, cultural imports always face probabilities of success or failure.

Bulgur abounds with facts in its favor. It is tasty and nutritious; has excellent keeping qualities; preparation is simple, requiring the simplest type of equipment and minimum fuel requirements; its versatility lends it to use in a wide range of recipes. These features make bulgur particularly well adapted to use in underdeveloped countries. Conversely, it has a great potential as a staple or specialty food in the sophisticated markets.

But the advantages, as we see them, will not assure automatic and immediate acceptance in countries where food is scarce any more than its innate advantages alone will guarantee bulgur a box-seat on the 50-yard line of today's supermarket. A new food article must be properly introduced, and the market must be serviced. The world no longer beats paths to doorways, if it ever did, in search of improved mousetraps.

A small group of U.S. wheat growers (from Oregon) rediscovered bulgur in 1950--right here in the San Francisco Bay area. In the four years that followed, they were instrumental in getting the Albany Utilization Laboratory to conduct research on bulgur. In 1952, the Oregon Wheat Commission set up a two-year study to test bulgur's properties and acceptance in Madras, India.

Prior to 1954, bulgur manufacture in the U.S. was carried on by a few small plants whose clientage was essentially of ethnic nature. In 1955, a new modern bulgur plant came into operation at Seattle, Washington. In the next six years, some 23 million pounds of bulgur went into export. While some of these exports were for cash, most of the bulgur moved under Title I, P.L. 480.

Last July, the USDA's Commodity Credit Corporation made bulgur eligible for distribution under Title III, P.L. 480. In the past ten months, 60 million pounds has moved into 27 countries through voluntary agencies. This is nearly three times the amount that moved in the preceding six years. And present indications are that this will be stepped up to the rate of 250-300 million pounds a year.

This outlook is the result of overwhelming acceptance for bulgur. But this acceptance did not just happen. It came as the result of the efforts of interested parties--USDA, voluntary agencies, wheat producers, and the manufacturer. The Title III bulgur program has proved effective in meeting the nation's food commitments

under the Food for Peace Program. It also makes sense in business terms of dollars and cents. For every hundred pounds of bulgur that moves under this program, the government has reduced its stocks by 2.6 bushels, which cost 56 cents a year to store. The recent trial program involving 60 million pounds of bulgur reduced government stocks by approximately 160,000 bushels of wheat, which was costing the government about $35,000 a year to store.

The expanded program of 250 to 300 million pounds per year will pull out of CCC stocks from 6-1/2 to 8 million bushels and will eliminate storage and interest costs that run 1.5 million to 1.75 million a year--every year that it remains in government hands.

Through these programs, millions of people in many lands are being introduced to bulgur. What a tremendous introductory effort for a "new" product. But, how will it sell in world markets? The price economics of world export markets for bulgur is far from simple. It involves the relative prices of other staple food grains which are available to the local market.

Omitting the arithmetic, we know that bulgur can be made available for export at an FOB mill price of about $3.90 per hundredweight. This is pretty cheap for a nutritious pre-cooked and easy-to-prepare cereal food. Increased production may make it possible for bulgur to be available at even lower prices.

Demand for bulgur can be developed further. It will sell if it is competitively priced with local staple food grains. Considering the present cost of bulgur and prospects for the future, I am convinced that bulgur will sell.

Discussion. Questions regarding foreign bulgur processing plants, comparisons of protein content of rice and wheat, relative use of red and white wheats, and bulgur processing costs and capacities elicited the following replies and comments:

Construction of processing plants in other countries is a problem common to all our foreign market development. The USDA has no opposition to local bulgur plants as, for instance, in India and Pakistan. We probably would have a favored position in wheat purchases because of our part in the development. However, we must remain competitive or a situation could develop similar to that of wheat milling in the Philippines.

Though rice protein may be lower than that of wheat, rice has been a long-accepted food. It was suggested that making comparisons was putting emphasis in the wrong direction. Wheat should be sold on its own merit.

Recently most of the exported bulgur has been made from red wheat moving under Title III of P.L. 480. Use of red or white wheat is at the discretion of the Secretary of Agriculture, but most of our stored wheat is hard red with 11 to 11-1/2 percent protein. Original specifications for bulgur were for white wheat and later attempts to use them for red wheat did not apply. Bulgur is similarly made from both, however.

Costs of processing bulgur run from $1.53 to $1.66 per hundredweight and average about $1.61 including a 31 to 32 cent bag cost. Total production capacity has been taken as a possible 500 million pounds per year. Now 600 million can be guaranteed, and a potential 1400 million per year has been lined up.

PROCESSING OF WHEAT INTO BULGUR

A. H. Brown
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My topic is the processing of wheat into bulgur. If we take time to examine published material and digest the information from the viewpoint of a manufacturing operation, two very interesting facts come to light.

First, the choice of raw material is not critical. Satisfactory bulgurs have been reported from white club wheat, white common wheat, soft white winter wheat, durum wheat, hard red spring wheat, and hard red winter wheat. References are even made to the use of emmer and eincorn for making bulgur in the Middle East when wheat supplies were short. Hard red winter wheat makes a bulgur that outperforms others in some of the canned bulgur products that are being developed. There also seems to be a flavor preference for hard red winter wheat in the bulgur wafers that are being procured by the Office of Civil Defense for rationing fallout shelters. I believe that most of the bulgur sent overseas has been made from hard red winter wheat, and you have already heard about the acceptance of the product.

The second very interesting fact concerns the processing of wheat into bulgur. An extremely wide range of processing conditions has been, and is being, used to convert wheat into bulgur, and surprisingly, the final products are not greatly different as a result of the processing conditions used. Instructions for making bulgur might well read like this: "Take wheat or other grain, water, and heat and combine in any proportion. Dry the product, remove the outer bran layers, crack the grain into coarse pieces, and put it in a cloth sack." These instructions sound very indefinite, but after I finish reviewing the many ways used to make bulgur from wheat, I believe that you will find the instructions to be a good summary of the technology of the industry.

Even the real experts cannot agree fully on what bulgur is or how it is made. A professor at the University of Ankara in Turkey made the following comments in a paper in Cereal Chemistry: "It is difficult to give a precise definition of bulgur because the method of its manufacture varies more or less according to the village or region where it is made .... The difficulty of finding wheats giving pale bulgur led to the rather common practice of dyeing them yellow .... In boiling, the proportion is often one part of wheat to two parts of water, and the time is 1 to 1.5 hours. Generally, there are three sieving fractions: thick bulgur, thin bulgur, and fine parts; the finest fraction being the smallest. Thus bulgurs of different regions are dissimilar: They may be dyed or left undyed, coarse or fine-grained, boiled for a short or long time, and may contain a variable quantity of hulls."

Another published report included observations on bulgur manufacture as practiced in villages in Lebanon. The director of the Industrial Institute of Lebanon wrote to us in 1957 and gave a very simple recipe: "The present method of manufacture of bulgur in Lebanon and Syria is to soak (wheat) overnight and then cook in an open kettle using a direct fire for five to six hours. The product is then drained and spread on roofs to dry."

I should like to compare the reported soaking and cooking steps as practiced by the natives of Lebanon and Turkey. You will note that the basic differences in these processes lie in the soaking and cooking steps.

Native preparation of bulgur

Location	Presoaking	Cooking	Drying
Turkey	wash only	Excess water, Boil 1-1.5 hr. in open pot	Sun
Lebanon	wash only	No excess water, Boil 3 hrs. in open pot	Sun
Lebanon & Turkey	Soak overnight	Excess water, Boil 5-6 hrs. in open pot	Sun

These methods of making bulgur are satisfactory for the situation in which they are used. Problems arise, however, when such methods are considered for making bulgur in large quantities. I shall now discuss, therefore, some of the processing changes that were made when centralized manufacture of bulgur began in this country. Since the soaking and cooking steps are at widest variance, emphasis will be placed on these steps with only limited emphasis on drying.

Two plants, Sunnyland Boulgour Company and California Sun-Dry Boulgour Company, are located in Fresno, California. These plants follow much the same procedure as that used by the natives of the Middle East. The soaking and cooking steps are combined. One company spreads the cooked wheat on screen trays to dry in the sun. The other company sun-dries part of its output, but uses a conventional rotary dryer for much of its product. The owner of the latter plant has stated that he finds no difference between the products dried in the sun and those dried in the rotary dryer.

A third producer of bulgur in the United States, Armeno Cereal Company, Northboro, Massachusetts, started operations in 1892. At that time, the operations were fundamental but present operations are more modern and quite different from those of the California companies. Wheat is first cleaned and is transferred to the type of rotary cooker widely used for making ready-to-eat cereals. Water is added to the cooker which is then rotated to wet and wash the wheat. Excess water is discharged, and cooking is carried out at about 2 psi for about 90 minutes while the cooker is slowly rotated. After cooking, the material is dried to about 10 percent moisture in a column-type grain dryer.

The next development in the commercial manufacture of bulgur in this country was a big one. When Fisher Flouring Mills went into the bulgur business, plant capacity was set up for about five times that of any other single plant in the country. A continuous process was the obvious choice for large-scale operation; consequently, the process is quite different from the batch methods used previously. Briefly, the process is as follows: Presoaking is accomplished by passing wheat through a series of three tanks in about 16 hours, starting at a temperature of about 125°F. and ending at a temperature of about 150°F. The soaked grain is then cooked in a continuous pressure cooker for 90 seconds at 259° (20 psi). After cooking, the grain passes through a small rotary dryer to remove surface moisture and then through a series of column-type grain dryers to complete drying. The following tabulation compares the processing conditions used by the four commercial producers of bulgur.

Commercial preparation of bulgur

Plant	Presoaking	Cooking	Drying
Sunnyland	Wash only	1 hr. open pot, No excess water	Sun or rotary dryer
Calif. Sun-Dry	Wash only	1 hr. open pot, No excess water	Sun
Armeno Cereal	Wash only	Pressure, 90 min. at 214°F.	Grain dryer
Fisher Mills	8 hrs. 125-150°F.	Pressure, 20 sec. at 259°F. (20 psi)	Rotary + grain dryer

An extremely wide range of processing conditions for converting wheat to bulgur is already showing up in the data summarized on these tabulations. Do you see what I meant when I gave the apparently facetious instructions for making bulgur? However, an even wider range of processing conditions is encompassed by processes worked out in various laboratories. For example, the Industrial Institute of Lebanon worked out a process in which both the presoaking and cooking steps were carried out in pressure cookers in a total process time of only 25 to 30 minutes. Alternatively, the presoaking could be carried out overnight in open tanks, followed by pressure cooking. The Western Regional Laboratory got into the act in the mid-fifties and came up with another presoak, pressure-cook process.

The Western Regional Laboratory again investigated bulgur manufacture in 1961-62 and came up with a quite different process, one that is actually a modernization and mechanization of the open-pot method used by the natives of the Middle East. The system is designed to make large quantities of bulgur continuously at low cost in readily available equipment. Basically, the process involves presoaking the wheat in increasingly hot water for 40 minutes, tempering the hot grain for 30 minutes, and cooking for 15 minutes in steam at atmospheric pressure. The entire soaking and cooking operation is carried out in simple, conveyor-type equipment. The tabulation below summarizes the presoaking and cooking conditions for the three proposed bulgur processes that I have just described.

Proposed bulgur processes

Location	Presoaking	Cooking
Ind. Inst. Lebanon	10-13 min. at 227°F. (5 psi) or overnight at room temp.	Pressure, 15-20 min. at 259°F. (20 psi) no excess water
WU (1957)	16-24 hr. at room temp. or 5 hrs. at 140°F.	Pressure, 3 min. at 316°F. to 10 min. at 259°F.
WU (1962)	20 min. at 150°F. 20 min. at 170°F. drain, hold hot for 30 min.	15 min. in atmospheric steam (212°F.)

Now I have attempted to summarize all of the process information given in the preceding tables. My purpose is to reemphasize the extreme range of processing conditions that can be used to produce bulgur of acceptable quality.

Summary of processes

Presoaking -- wash only; 5 hrs. at 140°F.;
24 hrs. at room temp; 10-13 min. at 227°F.
Cooking -- boil 1-6 hrs. in open pots,
15 min. at 212°F.; 3 min. at 316°F.; 20 sec. at 259°F.
Drying -- sun, rotary dryer, column-type grain dryer,
combinations of above
Total process time for cooking & soaking --
1-18 hrs. by native methods,
1-8 hrs. in commercial plants,
25 min. to 24 hrs. in proposed methods.

I believe you will agree that bulgur manufacture presents a most unusual situation. No other processed food can be made in so many different ways to give products that are hard to distinguish one from another. Even the nutritive values do not seem to vary greatly provided known precautions are taken. My own interpretation of the situation is that bulgur manufacture gives the engineer an opportunity to strive for maximum economy in plant investment and operating costs, thus providing good food at lowest possible cost for overseas use.

And now I shall change the subject almost completely and outline another operation that you will see this afternoon. I refer to the "puffing" or heat-expansion of bulgur. In its usual dry form, bulgur is vitreous or glassy to a degree that cannot be believed by any one who has not tried to chew it. As a matter of fact, one of the plants in Fresno, California, produced bulgur during World War II for the purpose of "sandblasting" carbon out of aircraft engines!

It doesn't take much imagination to think of cases where an "instant" bulgur would be useful. Puffing of the material proved to be the answer for some products. Exposure of bulgur to a hot (500°F.) air stream for 15 to 20 seconds expands each grain to as much as twice its original size, makes it crunchy and easily chewed, and imparts a slightly toasted flavor. The little puffer that you will see this afternoon is about the size of two large suitcases, really a toy. In a commercial operation, you would see a quite different piece of equipment, actually a corn flake or dry cereal toaster capable of puffing tons of bulgur an hour.

Puffing bulgur so that it could be eaten dry was essential to the development of the bulgur wafer for rationing fallout shelters. Puffing also puts the bulgur into a condition suitable for use in dry soup mixes, dry dessert mixes, and salad mixes, some of which you will see later today. I hope that all of you enjoy both the demonstration of bulgur dishes that will be displayed and the tour of the Laboratory this afternoon.

Discussion. The problem of possible insect contamination during sundrying was not investigated, because other drying methods are likely to be used. However, it is known that most sundried materials need cleaning. The Fisher patent on bulgur production is the only one presently known, but the possible patentability of the USDA process is being examined.

CONVERSION OF BULGUR INTO SPECIALIZED CONVENIENCE FOODS

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We have discussed bulgur, these past few days, as an historical phenomenon, as a pawn in international affairs, as a quick cure for the wheat surplus; and we have examined its nutritive value, its methods of manufacture, and its potential markets. Now, I propose to consider it as something to eat. Bulgur is a remarkable food, as the peoples of the Near East, who have been enjoying it for thousands of years, well know. Let me read to you a little piece about Kh-mah.

> "This prized dish was an Armenian ritual. It revived pagan appetites, virilized temperament, and restored earth roots. Kh-mah was a lusty food, composed of raw meat permeated with the stuff of the staff of life. Its ingredients were so basic and so simple--finely-ground lamb into which was mixed finely-ground bulghur. These were vigorously kneaded and wetted--wetted and kneaded--until the two became one--turning into a glistening rosy pink mass. Next, it was patted into a plump mound and placed on a platter. Then, it was garnished with chopped onions and parsley and dashed with paprika--giving it an impassioned complexion.
>
> "Here, indeed, was a glorious prelude for a wedding feast that primed primeval instincts. Devotees of the dish were soon plunging into its inviting substance --scooping heaping portions--devouring them with gullet-soothing arak....
>
> "The glutinous viscosity of Kh-mah made it immediate marrow for our hungry bones--gave us a feeling of might that caused us to tread the terra firma with a possessive step--injected blood into our eyes--emboldening us to stalk forth and conquer the world...."

Perhaps we in the Western countries have been missing something. Why isn't bulgur widely used here? Perhaps we can blame it on white bread. When we learned to produce white flour and became wealthy enough to do so and throw away part of the wheat, that white flour became a status symbol. Combined with sugar and fat and leavening, it produced delicate, rich foods for the wealthy. Now we all try to live like kings.

But changes have been creeping in in recent years. First there is a preoccupation with health. For real or fancied reasons of health, people are eating whole grains and dark breads. Witness the immense growth of the health food stores--and they are awash with assorted seeds, roots and berries, and all banked about with dark little lumps of bread. A loaf of ordinary white baker's bread isn't allowed in one of those places.

Then there is a change in fashion. Some of our finest restaurants are serving all kinds of dark and crusty breads and several are serving bulgur or boiled wheat. It's fashionable. The foods are exotic or novel--and those who set the fashions favor them, even if they were once the staff of life for peasants and had no snob appeal at all. These trends suggest that this may be the time to introduce bulgur to Westerners; but, in addition to glamour, we demand convenience and variety. And these qualities must be built into bulgur if it is to gain favor here.

If we consider bulgur for overseas trade, the requirements are no less stringent, though they may be different, and different for each country or community. Our task then is to examine bulgur to see if it fits any or all of these many and diverse requirements. How can you serve the stuff?

Mr. Brown has described to you the remarkable flexibility possible in the preparation of bulgur from wheat. No less amazing is bulgur's adaptability to use in a wide array of dishes. Our work in this laboratory has not been confined to studies of processing; perhaps the greater effort has been spent on investigation of special uses of bulgur. And the most specialized of all I shall tell you about first.

In 1960 we made a study of the problems that would be associated with feeding people in fallout shelters. Many Civil Defense planners had assumed that a ration could be made up easily from grocery-store items--that no particular problems were involved. But our analysis brought us to the conclusion that practically no foods presently available were suitable. This arises from the fact that the foods will have to be stored in the shelters for an indeterminate period. Almost all canned and dry foods on the market today have surprisingly short shelf lives because they don't need great stability. They move through the distribution cycle so fast that their lack of stability is not a handicap.

In addition to long shelf-life, shelter foods must satisfy other criteria. They must be generally acceptable (preferably a familiar food); studies of people under stress have shown that they will not eat a totally unfamiliar food or an unpleasant food until they are so hungry that they are in a greatly depleted condition. And this would defeat the purpose of keeping people healthy during a shelter stay so that they would be better equipped to face the post-attack period.

Obviously, a food for shelter stockpiles must be available, and in quantity. It should be in production on a large scale, or its raw material should be readily available and its processing simple and cheap. The cost is critical. If we can feed people for 50 cents a day, it will cost over $1 billion to stockpile food for the U. S. population for 2 weeks--and that doesn't include replacement cost for deteriorated food or the cost of surveillance and testing of the stockpiles.

The foods must be easy to serve in a crowded shelter. When you have only 6 to 12 square feet of floor space per person, elaborate serving methods are impossible. There may not be enough water to wash dishes properly, and disposal of large quantities of trash in the form of used disposable dishes and utensils is a serious problem. The foods should also be easy to prepare, not because there isn't time for preparation, but because cooking will create too much heat in a crowded shelter.

A compact food would be desirable--that is, something with relatively high caloric and bulk density. It's simply a matter of space for the food stocks in the crowded room. And last, the food should be relatively low in protein. This requirement stems from the possibility that the water supply in shelters may be short. A low protein diet is advisable in this circumstance in order to minimize physiological dehydration.

We found nothing on the market that would satisfy all of these requirements. The task, then, was to develop something. The obvious candidate for such a food was some form of cereal, and the obvious cereal was wheat. It remained to settle upon the form in which it should be prepared.

Plain wheat or flour would require too much fuel for preparation and this in turn would produce too much heat in the shelter. Bread, crackers, breakfast-type cereals do not have adequate storage stability for this specialized use and have other drawbacks. Bulgur was the best candidate, and specifically, the expanded bulgur that Mr. Brown has described.

In a fallout shelter habitability test, we tried this puffed bulgur, just as loose grains. But it was too messy--hard to serve, and it scattered about the room. Keeping the place clean is difficult. So we combined the bulgur with fat and malt

extract as binders and pressed it into a wafer. Here is the finished product. You will be able to examine it closely later when we show you various bulgur foods.

The flavor is bland to avoid satiety and to allow the wafer to be combined with other foods that serve as the flavoring agents and give variety to the diet. The wafer is firm enough so that it can be spread with jam or peanut butter, but it can also be crumbled and served with milk and sugar as a breakfast cereal, or mixed with sauce or soup as a main dish. As a convenience item, but one that offers some variety as well, it has no peer. For a complete meal, you simply add hot water to (for example) a dried soup mix, pour this over some crumbled wafers, and dinner is ready. This is the wafer that the Department of Defense is now obtaining to stockpile in the shelter spaces being marked this year.

Now let's go back to this list. As I've listened to the talks the last few days, I've been struck by how many of these criteria for shelter foods are also criteria for foods we might choose to send to the developing countries.

A good long shelf life is needed in countries that lack refrigeration facilities. It's also desirable if the foods must be shipped long distances.

Acceptability is a question. But these wafers were designed to allow variety in the diet--an essentially simple diet. Almost all people eat seeds or grains of some sort. And they combine them with domestic fruits, vegetables, insects or whatever. It is not inconceivable that this bland bulgur would fit very nicely into native dishes.

When we consider cost, we must compare bulgur or wafers to unprocessed wheat. The wafer, with a possible high caloric and bulk density, may be cheaper to ship. However, it may be more costly to package.

Wafers are easy to serve, because they can be served in almost any fashion. They might be useful in school lunch programs, served in various ways as is contemplated for their use in shelters. The wafer needs little or no preparation. In fuel-short countries, it should be especially valuable because it is fully cooked. In effect, we would be exporting fuel to these countries.

This wafer happens to be low in protein, on purpose. But it could be formulated with added protein, with vitamins, flavorings, almost anything you might want. Perhaps we have here something much more than just a food to be stored away for use only in a war that we hope never occurs.

Now for a moment, let's discuss the domestic market for bulgur. Here is where variety, glamour, and convenience are the guiding factors. Mrs. Heid of our Cereals Laboratory has developed a delightful array of bulgur dishes that range from soups to desserts. The flavor of bulgur combines well with other flavors, and the texture is suitable for many mixtures; thus, bulgur can be used in many favorite dishes.

Add bulgur to vegetable or meat soups. These mixtures can be fully dehydrated, as can salads. Mrs. Heid has developed dehydrated gelatin-vegetable-bulgur and gelatin-fruit-bulgur mixes that require only the addition of water and a little time to set to produce excellent molded salads.

When we come to main course dishes, the possibilities are limitless. Plain cooked bulgur is already on the market as a canned ready-to-eat product. This can be heated and served just as it is, perhaps with gravy or butter, in the fashion that potatoes and rice are served. When plain bulgur is heated with meat broth and herbs it is called pilaf, which is a standard item on the menu in Armenia and other Near

and Middle Eastern and Eastern European countries. Canned pilaf, too, is on the market now. Try it as a stuffing for poultry. Mrs. Heid is now developing a host of ready-to-eat main dish items; canned bulgur chili, Boston baked bulgur, Spanish bulgur, Bulgur au gratin, and Bulgur supreme. The last includes mushrooms and cheese. Roka wheatburgers are an ingenious device to stretch hamburger-meat. Part bulgur, part meat, they are topped with a sauce of mushrooms and blue cheese.

Now to the dessert. Three different flavors of bulgur Bavarian are dehydrated mixtures that are the essence of simplicity to prepare--and delicious to eat. Other desserts are Indian pudding and rice pudding. In order to go from soup to nuts, I suggest trying puffed dry bulgur--with a little salt added. It has a fine nut-like flavor.

It is frequently argued that development of new foods for the over-fed population of the U. S. is a waste of effort. I am loathe to think that this is true. Eating is more than just stoking of the human furnace. It is a major part of our social life and it is, or should be, an aesthetic experience. For these purposes, variety in food is essential. Here, in the humble bulgur, we have a plentiful, low-cost, but very attractive new food that can be served in endless ways and serve many purposes.

Discussion. The position of bulgur on our domestic market was commented on as one that may confuse foreign visitors from countries where we are emphasizing it. These people find bulgur is not frequently seen on grocery shelves, nor is it in common use. That available may be selling at 29 cents a pound, though production costs would be 4-1/2 - 5 cents a pound. The situation was suggested to be one calling for a better price advantage in the local market coupled with a promotional program extending over a prolonged period of time to make bulgur a common grocery item.

NEW WHEAT FOOD PRODUCTS

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This morning and over the past two days we have heard a very great deal about the virtues of wheat and the food uses of wheat and related matters. We have heard much about the use of wheat as bulgur and about the quality of wheat for making breads and other baked products. This is proper, for wheat is used to an overwhelming extent, around the world, as flour to go into baked products and pasta products, and it probably always will be. Bulgur, when its potential is finally attained, likewise will be used in great quantities throughout the world. These uses for wheat, however, by no means exhaust its capabilities in food products of value and appeal to human beings, wherever they may live.

I would like to talk about three other types of food products from wheat. They may never attain the prominence afforded the better known uses, but this does not mean that they would be quantitatively unimportant. They offer much for worldwide expansion of wheat usage, by making available attractive foods for which people will be willing to trade their resources, either collectively or as individuals.

The three general types are pearled wheat products, meat-like foods products, and high-protein dry products. The last includes preparations to be dispersed in water to form milk-like beverages or to be mixed into other foods in the manner that is used for the Incaparina mixture which Dr. Bressani described for you. You recognize, of course, that these are not particularly new in concept. Similar products

from other commodities have long been known. The important point is that we are beginning to know enough about the chemistry of wheat and the technology of foods so that greater advantage can be taken of the abundance of wheat, its high food value at low cost, and its wide acceptability.

In pearled wheat products the appeal is a flavor more bland than that of bulgur and a color that is much lighter. To many people unaccustomed to eating wheat steadily and in fairly large amounts, the blander products will be much more acceptable. Now, when I speak of pearled products, I do not necessarily mean the same sort of thing as pearled barley, which is produced by grinding away all bran and outer tissues down into the endosperm by purely mechanical means. We have in mind more delicate and refined processes.

Figure 1 is a greatly magnified section of a wheat kernel showing the various tissues. Two of the bran layers are of special interest. They are the aleurone and the testa, or seed coat. The thick outer layers of bran are relatively easily removed mechanically and are not of great interest with respect to food value. They are high in fiber, somewhat pigmented, and appear to have relatively lower amounts of protein and other nutrients than other structures. These layers are customarily removed from bulgur. The layer of large nucleated cells between the endosperm and outer bran layers is the aleurone tissue. It is a highly active group of cells metabolically and is rich in food value. It is important that these cells be retained in whole-kernel food products or that their nutrients be retained. In bulgur, for example, the processing transfers the bulk of aleurone nutrients into the endosperm region. Unfortunately, for our present interests at least, the colored materials from the thin, heavily pigmented layer of bran (testa or seed coat) lying immediately on top of the aleurone layer are also transferred to the endosperm.

Figure 1. Magnified section of a wheat kernel.

Now, what we are proposing to do is to remove by mechanical or other means, the other bran layers down through the heavily pigmented layer, but to retain as much of the aleurone as possible. Then we want to transfer the aleurone nutrients to the endosperm where they will be stabilized to a greater extent. Following this operation, we want to decolorize the exposed kernel tissues to achieve a clean creamy white color, over-all.

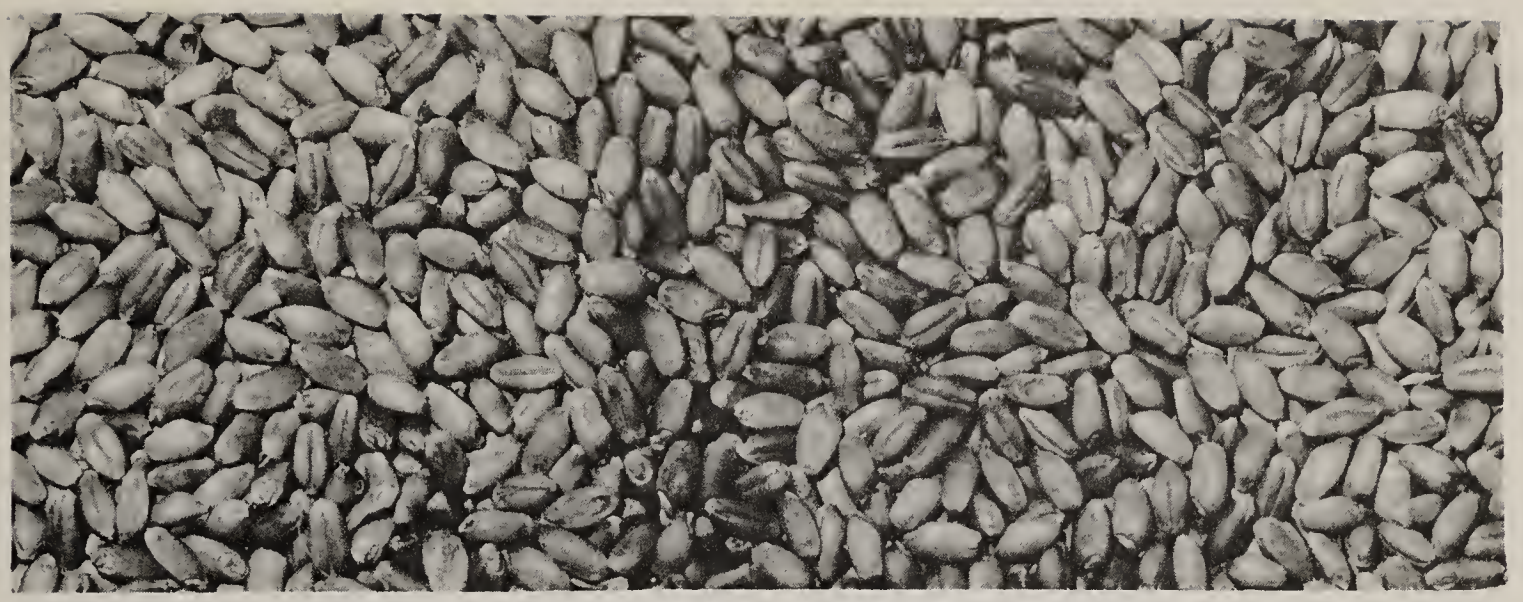

Figure 2. Sample of medium-protein hard red winter wheat.

Figure 3. Outer bran layers have been removed mechanically.

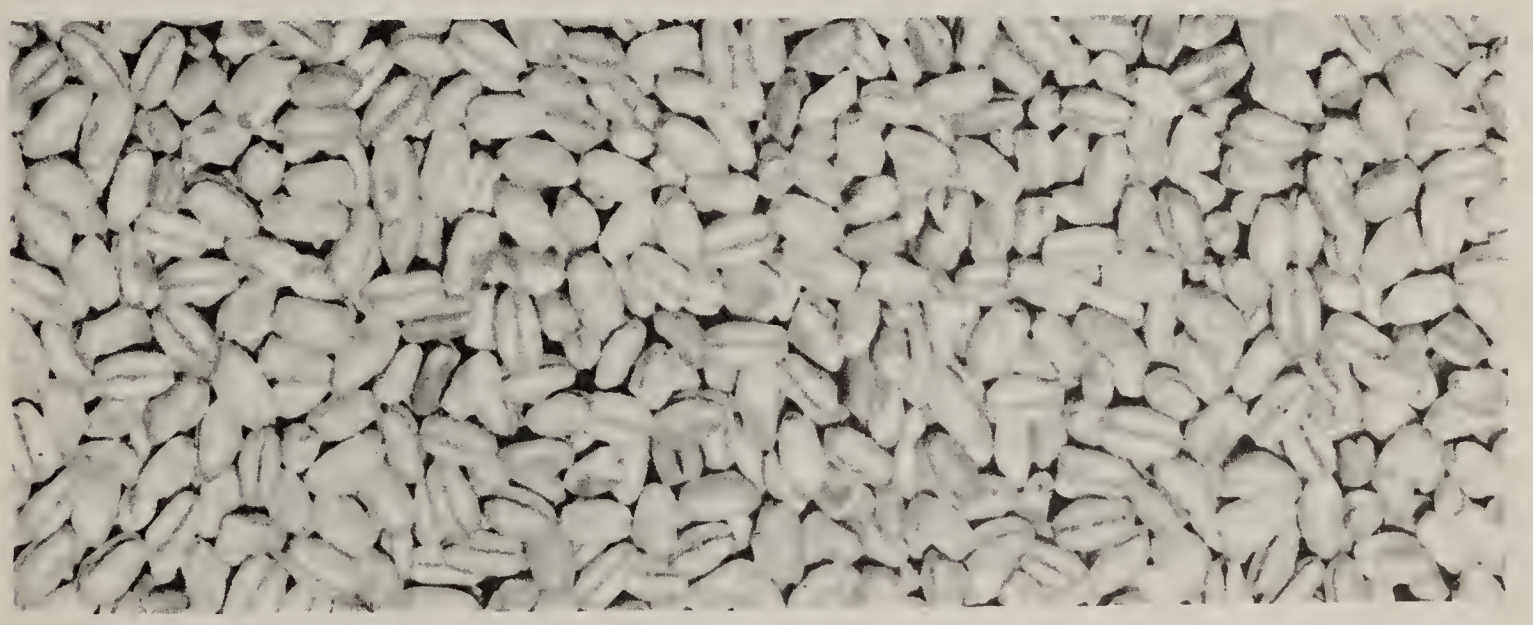

Figure 4. Decolorized debranned wheat.

As you can see, we have some real problems before us, but let me next show you how well the debranning and decolorizing steps are coming along in our exploratory work in this area. Figure 2 shows a sample of medium protein Kansas hard red winter wheat. This is a fairly light wheat to begin with. The kernels are large and plump, a bit more on the chalky side than on the vitreous side--as the millers would say, "a lot of yellow belly." Figure 3 shows the same wheat after the outer bran layers have been removed by mechanical means. As you can readily see, a great many of the kernels are still dark and translucent rather than chalky. Note also, however, that the kernels are physically virtually intact. The ends are not ground down as in pearled barley.

Figure 4 shows the debranned wheat that has been decolorized, or bleached. The color is decidedly still on the creamy side, but the overall effect is quite good. The mottled and generally dark appearance of the kernels has been replaced by a fairly uniform chalkiness, and the crease of the kernels is not greatly intrusive. The color of this sample is no worse than that of a very large amount of the rice that is common in world use. In this country we tend to think of all rice in terms of the finely polished, very white product characteristic of our domestic industry.

Our work with pearled wheat products has only just begun and is still exploratory. We have gone far enough so that we are quite convinced that good products can be obtained at reasonable costs. Perhaps the greatest problem will be the high retention of nutritive values. Some of the texture modifications we would like have so far been obtainable only with agents that are pretty rough on thiamine.

The next type of product I want to discuss is the high-protein type in powdered or granular form. Milk-like products from wheat flour were not apparently feasible until the advent of air-classification milling. Nowadays, however, flours are available at reasonable costs that contain from 25 to 30 percent or more of protein and that are quite finely divided. Processing to modify the gelation tendencies of the starch and to solubilize the gluten proteins sufficiently to make them suspendible should not be difficult or expensive. Experimental work has just begun and I cannot make a factual report at this time. Following these development phases, attention will then be shifted to formulation of the final product by supplying the vitamins, minerals, and supplementary protein necessary to match the food value of animal milks.

I have assumed that all of you understand that such a cereal liquid food is not intended to replace or even to compete with dairy milk. It is intended, of course, for the vast regions where dairy products are rare, to say the least. Also, I assume you recognize that development of milk-like products from cereal flours is not the same category as a silk purse made from a sow's ear. There is a no more abundant source of food protein than wheat. Flour is inexpensive, bland in flavor, and already light enough in color. So you see, many of the problems faced in development of milk-like foods from other plant materials are non-existent with wheat.

Somewhat the same situation holds for the granular products envisioned for general supplementary use in overseas diets. With this type of product dry gum gluten can be used to furnish any desired base-level of protein to be used with supplementing materials. Minerals and vitamins would be added for nutritional balance. It is not especially necessary for the final mixture to be dispersible, though it may be. Finely divided powders can be added to beverages or soups; whereas coarser, granulated forms could be added to sauces, gravies, stews, and the like. Since the products would be concentrates, essentially, they would not need to be used in large enough quantities to intrude unduly on the textures and flavors of the foods to which they are added.

Stability of the concentrates should not be any great problem as long as the products can be kept dry. Wheat gluten and flour fractions free of bran and germ

materials are rather surprisingly stable, so long as they have not been heated--possibly because of natural antioxidants present. Addition of extra allowable antioxidants would, however, be desirable also to protect added fat-soluble vitamins.

A third type of food product is one which is perhaps the least novel. Vegetarians around the world have long been using wheat gluten as a base for products resembling meats in flavor and texture. Various canned commercial products are also available. One American organization has plants in seven foreign countries. Thus, the essential practicality of such products is well established. Innovations in texture and flavor characteristics, however, provide plenty of opportunity for improved products and new products in canned, ready-to-eat form for markets in countries where meats are scarce and high priced. These would be dollar markets well worth seeking.

Less-expensive meat-like products would have wider markets, as is obvious, and the larger opportunity lies in this direction. The first step would be to get rid of the expensive tin can. This means dry products, and dry products lead naturally to smoking and salt-curing as means of preservation. One major type of this kind is hard sausage. Hard sausages of many kinds are common throughout the world, and acceptability can be taken more or less for granted, provided the gluten-based products are tasty and good.

The first step in development of this type of product is converting gum gluten to a semi-moist or dry condition in which it can be eaten directly or can be cooked in water, if desired, and still retain a good resemblance to meat-based products. Some adroit modification of gluten's properties will be necessary, but we now have enough knowledge of its major characteristics and enough research tools to keep track of modifications as they progress during processing, so that the task is entirely feasible.

Formulation of final products should be simple, once the primary texture is taken care of. Selection of spices and seasonings for the various well-known kinds of sausage, such as salami, linguica, pepperoni, karbassi, or what have you, is straightforward. The fat component can be well controlled by use of the wide variety of hydrogenated vegetable oil products available nowadays, although it may be advisable to use animal-derived fats for flavors. Stabilization of fatty components is not the problem it once was. Cellulose casings may very well give way to some of the newer films that are coming into prominence. Heavy smoking of the products is all that remains to top off the desired flavor and to enhance stability. Thus cased, smoked, and salted, the products should be stable without refrigeration for considerable periods and be a welcome relief at relatively low cost to some of the rather monotonous diets prevailing in many world areas. I should add that cost and texture can be modified and regulated to some extent by blending puffed bulgur into the products in varying proportions.

Somewhat similar dry products are jerky and pemmican, which are traditional frontier foods in our country that were adopted from the Indians. Jerky is smoked, salted strips of dried meat, and when I say salted, I mean salted! I can remember as a youngster trying to eat some venison jerky that had been parboiled twice to leach out some of the salt. It was still too salty for me, but the adults appeared to relish it.

Pemmican is smoked, dried meat that has been ground or pounded into sort of a stringy pulp with copious amounts of fat. When available, dried currants or other berries are incorporated. The mixture is often packed tightly into buckskin bags in northern climates, but in warmer climates, animal casings are used. To our sophisticated palates, these two products probably might not seem very delectable, but to people on restricted diets they could be quite attractive. Modern versions of both products, I feel, could be made from gluten and accessory materials to have good acceptability at low cost.

With the array of surprisingly good flavoring materials available today, gluten-based products resembling dried, salted fish flesh are good possibilities that can be put up in smoked or non-smoked forms.

I have talked at some length here about new types of food products or uncommon types of food products that are derivable from wheat. Some of them may seem a little fanciful at first, but let me point out again that several of them are already known to some extent. Others have been taken far enough in the laboratory to demonstrate their feasibility. The primary requirement for most of them is a satisfactory technology of production. With the present knowledge of wheat and other food constituents and with the present state of development of food technology, in general, these products represent real opportunities to increase the usage of wheat throughout the world by a sizable amount.

Discussion. The point was brought out that removal of the pigments from the partially debranned wheat was done experimentally by bleaching with such agents as hydrogen peroxide or chlorine dioxide.

SUMMARY OF CONFERENCE

George W. Irving, Jr.
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This conference has covered wide territory--virtually the entire world and its peoples, those that now exist and their rapidly increasing progeny. In brief, seven statements will summarize the conference:

1. There is much hunger in the world.
2. There are means for appeasing this hunger.
3. Wheat can be a major factor, being a nutritious food and existing in abundance, although not produced where the need is greatest.
4. In order to bring the supply to the areas of need, a vast array of local and general problems of traditional practice, ignorance and illiteracy, economic insufficiency, and cost must be understood and solved.
5. The solution to food deficiency must eventually be met by economic development in the areas of need.
6. Raw wheat may not always be the most useful form of food to supply needy areas, but wheat is a very versatile commodity and can be processed to serve varied demands; bulgur is already showing much promise and other wheat products appear to offer future possibilities.
7. International trade in foods has economic and political connotations; political pressures more generally determine prices than economic "laws."

The orderly development of markets for U. S. agriculture is both a legitimate objective and a unique opportunity, afforded by various subsidized export programs. These programs must be accompanied by research, technical aid, and educational programs. As developing countries begin to emerge and buying power is created, danger exists from spiralling inflation if foodstuffs cannot be provided in sufficient supply for emergent populations. The U. S. supply of food can be a major asset to apply to shortages during transitional periods and can, if properly applied, create lasting markets.

The cycle of poverty prevails in many areas and will be hard to break. Education is needed and illiteracy exists in most of the areas of need. As a reasonable approach to the world food problems, better knowledge of food availability and nutritional status is required, not only on a country-by-country basis but from area-to-area in most countries. Surveys are being made but much of the available statistics on population and food availability are questionable but improving. In many countries government interest is lacking or inadequate. Kwashiorkor exists as, perhaps, the major physiological manifestation of undernourishment. This, of course, is related to protein insufficiency and is limited to preschool age, weaned children. The splendid work of INCAP has indicated that vegetable protein, properly blended, will serve very well to enrich infant diets to control this malady. UNICEF likewise has done much throughout the world to help bring this problem under control. General undernourishment, largely caloric deficiency, also abounds. In many instances, in addition to a food supply, a technology is needed for preserving and distributing foods suitable for each local condition.

In surveys in Africa, observations of diets that were very low in animal protein were not always accompanied by malnutrition. More clinical surveying is indicated and careful interpretation of data must be made because of over-riding parasites and endemic malaria, which confuse the nutritional symptoms.

The milling of wheat offers an opportunity for protein enrichment of diets under specific conditions. Certain mill fractions (red dog and shorts) are relatively rich in amino acids (particularly lysine), which would make them useful supplements for protein-poor diets. Wheat, by itself, provides what appears to be adequate protein (quantity and quality) to meet nutritional standards for protein. However, it is not an exceptional source of any one nutrient and to the extent that diets are modified with food of lower protein levels (e.g., sugar, fats, dates, cassava, to mention a few), the entire diet may become weak in protein. Furthermore, wheat must be processed, which will add cost, in return for more useful products.

The suggestion is made that wheat, as a high source of glutamic acid, may have higher nutrient value than it is generally considered to have. Furthermore, there is some evidence of value of increased cereal diets (as opposed to high fat) in control of obesity and, possibly, atherosclerosis.

In the very interesting tests conducted in a German orphanage following World War II, certain preconceived notions on nutrition were upset by findings that unfortified wheat (except for calcium) of 70 percent extraction was very nutritious, and indistinguishable from 100 percent extraction fortified wheat when fed up to levels of 70-80 percent of the calories in children's diets. Furthermore, in carefully controlled tests, the nourishment, as measured by height and weight gain, was not improved by tripling the animal protein in the high-level bread diets with dried whole milk. The surprising fact to us, that this important experiment has not been more widely appreciated, indicates that the studies could well be repeated to provide the emphasis needed to convince nutritionists of the value of wheat as a human food.

In order to make the excellent nutritional properties of wheat more readily available and useful to many peoples of the world, it will have to be converted into palatable, attractive forms. Bulgur is an example of a wheat product that is being very well received indeed. Nutritional studies of this product indicate that nourishment is not unduly harmed by the process. Bulgur has nutrient qualities about equivalent to whole wheat.

Public Law 480 has proved to be a most progressive piece of legislation. Its use together with an adequate research program to develop new products and create enlarged markets is essential under current world conditions. Cooperative efforts of grower associations, USDA, volunteer groups, etc. are developing new markets.

The development of food-deficient nations and the projected population increases represent huge potential markets for wheat, if local conditions are understood and properly dealt with.

One of the problems of introducing an unfamiliar product or technology into an underdeveloped country is related to the illiteracy that is all too prevalent. An opportunity exists to move rapidly if a ready-to-eat product is made available at low cost. No written instructions are needed to eat a doughnut, although a higher level of literacy might be required if the wheat were to be milled and used, for example, in bread making.

Some of our biggest export markets (Europe and Japan) are threatened by competition. High-quality wheats are demanded and the United States has not always had such wheat available at the costs required. Canadian wheat has made great inroads in these markets and in the Philippines. The European market is very likely to become even tighter with the Common Market showing signs of being quite protectionist in agricultural trade policy.

A successful program under P.L. 480 has been the export of bulgur (60 million pounds in 1962; 230-300 million pounds scheduled for 1963). Engineering process studies of bulgur production have demonstrated that good bulgur can be made of a wide spectrum of wheat types by quite diverse production methods. Engineering and economic considerations will almost certainly determine the bulgur process to be used.

Bulgur is a very versatile product and can be used in many ways--eaten out-of-hand or used as a base for instant cooking recipes. In addition, the expanded bulgur has fitted well into requirements for emergency food supply for fallout shelter wafers. The Office of Civil Defense has negotiated its first contract for 500,000 pounds of bulgur wafers and has announced plans to procure up to 120 million pounds.

The great versatility of wheat extends beyond the bulgur products. Dry, dispersible-in-liquid, protein-rich foods from wheat fractions now appear possible by means of advanced milling techniques and air classification. Meat-like cereal products using gluten as a binder appear to offer market potential, both at home and abroad.

In considering export market opportunities for wheat and wheat products, we were advised not to overlook certain facts that exist. The great free world market in foodstuffs that began its modern development when

"England won her proudest bays,
In good Queen Bess' glorious days,"

have ceased to exist. National self-sufficiency and protectionist laws began to break down in sugar markets as early as the Napoleonic wars. The Britain-protected free trade was just about terminated during the depression of the 1930's. Political considerations can repeal all economic law.

The need for food exists; the resources and technical knowledge for production are available; agencies and individuals are willing and able to devote great resources to market development; wheat and wheat products fit many of the individual requirements; and yet a major undertaking remains to fit together all the pieces of this intricate puzzle that can be a foundation for an unparalleled international strength.

CONCLUDING REMARKS

Clifford R. Hope, President
Great Plains Wheat Inc., Garden City, Kansas

The very fine summary of this meeting by Dr. Irving leaves little to be said about the program, but I am glad to make a few comments in closing. My comments are those of a listener in the meeting.

We owe a debt of gratitude to Dr. Copley and his able assistants for the fine arrangements which have been made in connection with the meeting. I want to thank all who participated for developing such a good program--the speakers, those in the audience who stimulated the discussions, and those who gave such close attention to all the talks.

The wide range of information presented has opened the eyes of each attendant to new parts of the problem, no matter what his background or knowledge. Because so much has been offered in the past few days, it will be valuable to have the printed proceedings of the meeting for further study. The information reported has given us all a better opinion of our product, and I believe it is well for those concerned with "The Role of Wheat in the World's Food Supply" to gather from time to time for further discussions of our problems and progress.

I always appreciate the opportunity to say something about research in the development of new and improved foods and the means for introducing them to new markets. Here it fits in especially well. I am not against production research, for it has made possible our present abundance. But marketing research did not come along until later and we have much to make up in this direction. It should be given special emphasis.

I have been impressed by the scientific reports presented here and on the work back of them. They give the information that research is not always the romantic endeavor pictured by the public; it is often hard work, even drudgery. But researchers are stimulated to continue by the vision ahead.

In conclusion I wish to express a feeling which I know, from conversations and, from what I have overheard, is shared by many of those present. This is that great progress has been and is being made, and we can look forward with confident hopes of more to come.

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